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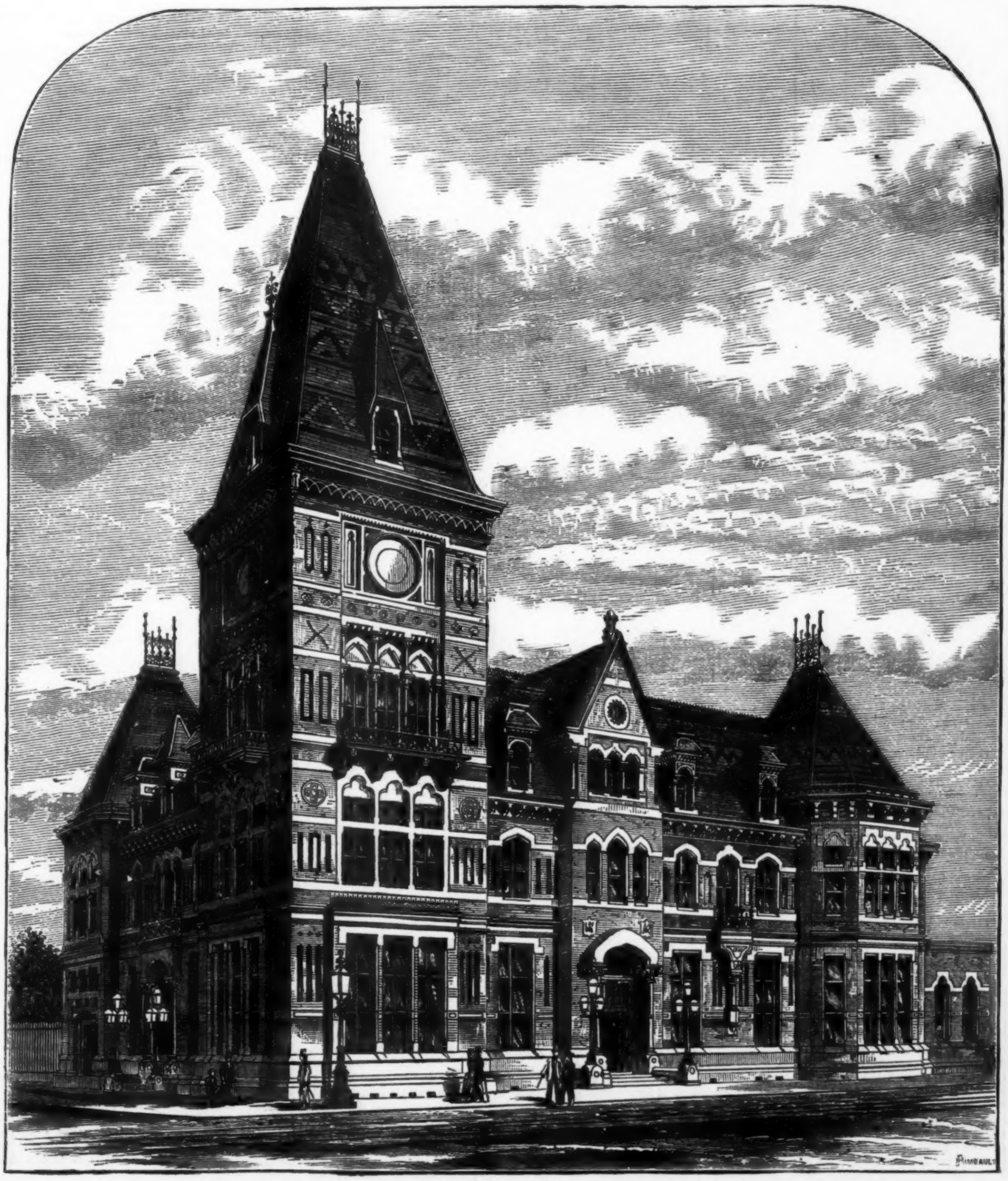
NEW PASSENGER STATION AT WASHINGTON, D.C.

Our illustration shows the passenger station recently erected at Washington, of the Baltimore and Potomac Railroad, a line belonging, as will be remembered, to the Pennsylvania Company's system. The building is situated at the corner of Sixth and B Streets, with a frontage of 137 feet in B Street, and a depth in Sixth Street of 95 feet, the main entrance being from the latter, and the ladies' entrance from the former. On the ground floor there is ample accommodation for passengers, including a general waiting-room 40 feet by 68 feet, a ladies' room 23 feet by 45 feet, a gentlemen's room 20 feet by 37 feet, and a restaurant 45 feet wide by 55 feet long, with kitchen and cellars, and all other necessary appliances. There are besides on the same floor luggage-rooms, offices, lavatories, etc. The upper floors are laid out as offices for the company, and some dwelling rooms. The walls are formed of bricks, with a facing of pressed bricks, relieved by dressings of Ohio stone, and a base course of Richmond granite, rising to the sill level of the windows on the ground floor. The entrance steps on each side are also of Richmond granite, and the shafts of the columns at the entrance are of polished Aberdeen granite. A considerable amount of terra-cotta decoration has been introduced, and with good effect. The interior of the building is fitted up with hard woods of different colors, and oiled, and the floors of the principal waiting-room, restaurant, and lavatories, are laid with tiles. The rooms and offices are heated by steam. To the rear of this station are placed the train sheds, forming a strong contrast to the really elaborate building we have described. It is intended, however, before long to remove them, and replace them by a roof 130 feet wide and 510 feet long.

REFRIGERATING FREIGHT CARS.

The Tiffany Refrigerating Freight Car is now in successful use for the transportation of meats and fruits from the Pacific coast to the Atlantic cities. Beef, strawberries, and other perishable commodities are transported and delivered perfectly sound and fresh after a journey of from eight to sixteen days.

In size and appearance the Tiffany is precisely like (with the exception of an ice-box) the ordinary freight car; in weight 6,000 pounds lighter than this style of car has ever been made before. In construction it is rendered impervious to outside temperature by dead air spaces between the three partitions of wood, which are lined with carpet of felt paper. An ice-box on the top runs the whole length of the car, and can be filled without disturbing the freight. The air allowed to enter is reduced to the proper temperature by passing through the ventilator under the ice in tubes, while the warm and impure air is forced through pipes that run through the rafters supporting the ceiling. This peculiar construction is especially valuable, as insuring safety in transmission in both hot and cold weather, the experiment proving that with the temperature at 30° below zero and the car standing still for 52 hours, the freight will remain unaffected.



NEW PASSENGER STATION AT WASHINGTON, D.C.—BALTIMORE AND POTOMAC RAILROAD.

J. B. HOYT'S FURNACE FOR THE COMBUSTION OF BITUMINOUS COAL WITHOUT SMOKE.

Among the few novelties in steam engineering at the Exhibition, there was nothing more really new than the above-named furnace. It marks quite a departure from old lines in several respects; and the novel points in it are most ingenious and effective. A great deal of ingenuity and study has been expended in attempts to solve the problem of completely consuming those varieties of coal which contain, in more or less proportion, gaseous matters; or which evolve gases when first placed in the furnace, which must be consumed in that form, if at all, and coming under the general head of bituminous. If completely consumed, of course, smoke would not be a product of the operation, and the carbonaceous matter, which becomes condensed to form it, would render up its quota of heat, and, at least, some addition would be made to the economic value of coal so burned over that whose consumption is accompanied by smoke. Previous to the advent of this furnace, however, but very indifferent success has been met with in this direction. We hear occasionally of furnaces which burn their own smoke; but, in the first place, it is practically impossible to burn smoke when once formed, from the fact that the particles of solid carbon composing it become so intimately mixed with the products of the combustion of that part of the fuel which is really burned, and with the free and incombustible nitrogen released in the operation, that there is no possible means of bringing it in contact with the necessary oxygen at a temperature high enough, and smoke once formed is never burned, or, at least, but very slightly; and, in the next place, it is equally true that no furnace has hitherto been constructed which would not give off considerable volumes of dense black smoke when first fired upon.

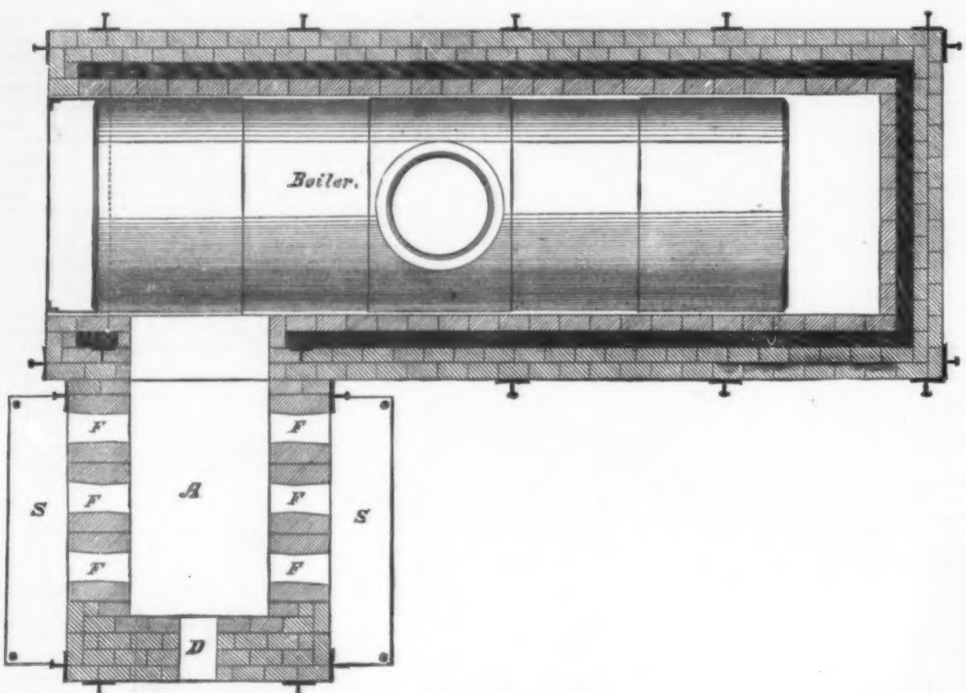


Fig. 1.

A furnace, in which the varieties of coal is consumed without smoke, must prevent its formation by the complete combination of the combustible parts of the coal with the oxygen of the air before smoke is produced in any part of the operation, otherwise its escape from the chimney cannot be prevented.

As the oxygen for combination must come from the atmosphere, where it is mingled with a large volume of nitrogen, the conditions necessary to the complete combination of the carbon and hydrogen of the coal is difficult to bring about, from the fact that this inert (nitrogen) gas acts as a great absorbent of heat in the operation. So far as that portion of the coal which retains the form of solid carbon and combines without previous volatilization is concerned, there appears no difficulty in effecting its practically complete combustion; but when bituminous coal is first placed under the influence of the heat of a furnace, as in newly firing, its volatile constituents become distilled away from it as a condition precedent to the combination of any part of it with the oxygen of the air. This gaseous matter contains all the hydrogen and part of the carbon of the coal, and if distilled without access of air, as in the manufacture of illuminating gas, the compound is quite transparent and free from anything approaching the nature of smoke; but when distilled, as in the ordinary furnace, the hydrogen, which combines with the oxygen much more readily and at lower temperatures, becomes in part so combined, leaving that part of the carbon previously associated with it in minute solid particles, which render the mixture of gases escaping from a chimney visible as smoke.

One of the pre-requisites, then, to the complete combustion of these gases, is that, before they are brought into contact with the air, they shall be raised to a temperature sufficiently high to permit of the oxidation of the carbon contained in them. But not only must the gases be themselves made sufficiently hot *before* meeting with oxygen, but the air containing the latter must also be highly heated—probably, as highly heated as the gases themselves—*before* meeting the gases; then there must be sufficient air to supply the oxygen required and not so much as to carry off heat uselessly, if highly heated, or to chill the contents of the combustion chamber, if cooler than the gases with which its oxygen is to combine. The combustion of the gaseous part of the coal must go on somewhere above the coals, and is, probably, the easier accomplished the sooner it is done after its formation. The solid carbon is made to combine in a practically complete manner by the passage of the proper quantity of air through it; but here, as in the case of the gases, the quantity of air admitted requires to be nicely regulated; for if either too much or too little be allowed to enter, the carbon first oxidized to CO_2 in its passage upward through the hot coals appropriates another equivalent of carbon and passes off as CO; and when the bed of coals is very thick, it is probable this always takes place to some extent, and adds to the hydrocarbon gases distilled from the coal something more requiring a supply of heated air to complete its combustion. The air admitted above the coals, too, must be as intimately mixed with and distributed amongst the gases as it is with the solid coal on its passage through it, and this intermixture must occur as near the surface of the coals as possible, or as soon after the formation of the gases as can be brought about, in order that they shall not pass away sufficiently to become cooled below that point at which the carbon in them will combine.

A furnace, therefore, which shall consume bituminous coal without smoke must permit of the regulation of the quantity of air both above and below the grate, provide for a thorough distribution and mixture of the latter with the gases from the fuel, raise the air admitted above the grate to a high temperature before admixture with the gases from the fuel, and, lastly, "raise the distilled gases themselves before permitting them to mix with the admitted air," to a temperature high enough to allow the carbon contained in them to oxidize into CO_2.

With the exception of the last, furnaces have been constructed which satisfy more or less these precedent conditions; but until the appearance of this apparatus no attempt had been made to heat the distilled gases, except at some considerable period after or distance from the point of their formation, and thus after their hydrogen had been burned out, when it was too late, and the smoke was already formed. It is believed, too, that this is the only furnace using the natural draught which has succeeded in heating the air admitted above the grate to a sufficiently high point to render complete combustion possible.

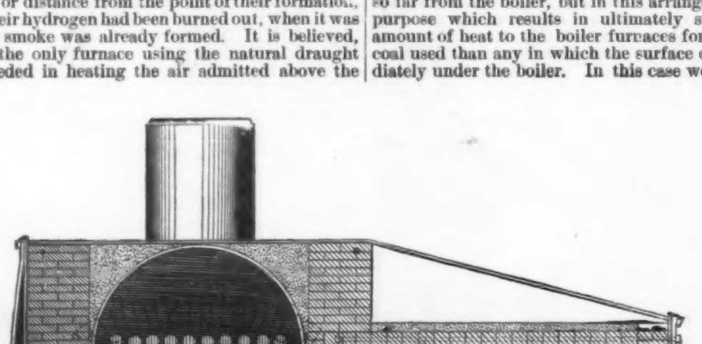


Fig. 2.

The furnace shown in the figures was placed in connection with the boiler which furnished steam for the Shoe and Leather Building at the Exhibition, and so far filled the conditions of complete combustion of the bituminous coal used in it during the entire six months that, except for a short time at the starting of a new fire, no smoke was ever to be seen issuing from its chimney.

Fig. 1 shows the furnace in sectional plan, and Fig. 2 a vertical section through the oven or furnace. In Fig. 1, A is the grate, D an opening in the brickwork, situated similarly to the ordinary fire door, for use in starting fire, extracting clinker, etc. In this opening there are placed two doors, one within the other; the inner one perforated with a large number of small holes, so that air might be permitted to enter above the grate at this point, if necessary (which, however, is rarely the case), in the regular operation of the furnace. S S are shelves upon which the fuel is laid preparatory to firing. F F, etc., are small arched openings, slightly conical, with the small end toward the fire, and the bottoms of which are a little above the level of the grate bars. The coal is piled upon the shelves so as to completely fill the openings F F, and practically prevent the air from entering through them. In Fig. 2, O O, etc., are small holes through which air is admitted in a large number of small streams, regularly distributed in the length of the furnace. These holes communicate with hollow spaces built in the walls and furnace crown, and these spaces again with the outer air, at the greatest possible distance from the furnace, so that they may have the longest distance to travel under the heating influence of the walls before entering the furnace. The air finally passes through the hollow arch of the furnace before issuing from the holes O O, etc., and as this arch, owing to the exceptionally perfect combustion in this furnace, reaches a very high temperature, the air is made very hot just previous to entering the furnace. Below the opening D is the usual ashpit door, through which air is admitted through the grate, and both at this point and at the holes O O, etc., provision is made for regulating the quantity of air which may pass through them.

The bed of coals is purposely carried very thick—about three times the thickness usually allowed in the ordinary furnace—and to feed new coal to the fire it is merely pushed *under and into* the body of the incandescent coal upon the grate, the latter being made to incline downward from the sides toward the middle to facilitate this operation. A rod of iron or wood is used to thus force the new coal through the openings F F, and when the operation is completed new coal is piled against the openings to prevent access of air.

This operation is simplicity itself, but it subserves a purpose which has heretofore been entirely ignored in the burning of this kind of fuel, that of heating the distilled gases to a high degree before presenting them to the admitted air: they, being distilled within the body of the incandescent fuel upon the grate, become raised to a very high temperature on their passage upward through it, when upon their meeting the highly heated air admitted through the holes OO, etc., the carbon, as well as the hydrogen, combines, complete combustion takes place and no smoke ensues. That this is an essential part of the operation is proved by the fact that even in this furnace, where every other necessary condition obtains, the least quantity of coal fed to it by placing it on the surface of the fire results in the production of smoke; in fact—as experimentally witnessed by the writer several times—a change in any of the conditions mentioned above would have the same result; but there was not the slightest difficulty in operating this furnace continuously without smoke by the exercise of the most ordinary care in the regulating of the air admission and the manner of firing.

When in regular operation, that is to say, when the fire has been in operation long enough to bring the furnace crown, bridge wall, and other flue walls leading to the chimney up to the high temperature which it maintains steadily there after, whether in newly firing, or while the feed holes are simply closed with coal, nothing but clear, transparent, but very highly heated, gases pass over the bridge wall and along the chamber under the boiler to the flues in the back connection, as was readily seen through windowed peepholes placed in the brickwork; while a mere handful of coal thrown on top of the hot coals immediately filled the entire chamber and passages under the boiler with such dense black smoke as to preclude all observation of what was going on until it had passed away.

It does not accord very well with preconceived ideas or general practice to remove the hottest part of the apparatus so far from the boiler, but in this arrangement it subserves a purpose which results in ultimately supplying a greater amount of heat to the boiler furnaces for a given weight of coal used than any in which the surface of the fire is immediately under the boiler. In this case we have just the reverse of the cold iron of the boiler for the gases in process of burning to come in contact with; for the furnace arch when in continuous working is always at a bright white heat.

The temperature maintained in the furnace is exceptionally high, as is shown by experiments made by Theron Skeel, C.E., upon a similar one now in operation at Mr. Hoyt's belting manufactory in New York, and which he estimates to be about 3,500°. During his experiments to determine this, the furnace melted successively, when exposed in a crucible on the bridge wall, zinc, silver, copper, cast iron, wrought iron wire, and, finally, the crucible itself; and on one occasion ordinary firebrick, similarly placed, was partially melted down in the furnace at the Exhibition, as witnessed by the writer.

The experiments of Mr. Skeel were made with a view to determine the saving of fuel as well as the prevention of

smoke, and to make them complete, and the results comparable with those from some ordinary furnace, similar experiments were made with a furnace and boiler at the New York Hospital, and he found from a comparison of the two that the comparative value of a highly bituminous coal ("American Cannel") from Ohio for commercial purposes to be as burned in

Hoyt's furnace	11·68
Ordinary furnace	9·56

in the proportion of 122 to 100, or about 22 per cent. in favor of the Hoyt furnace.

Mr. Skeel considered the operation of the furnace at the New York Hospital as fairly representative of the ordinary practice, with this kind of coal consumed at the rate of about 10 lbs. per square foot of grate per hour, and as economical a use of this coal could be made in the Hoyt furnace at the rate of 20 lbs. per hour without smoke as could be had with the ordinary furnace with large grate, carefully fired in alternate sections at as slow a rate of combustion as 5 lbs. per hour per square foot of grate.

With the semi-bituminous kinds of coal obtained from the Eastern mines, of course the difference in economy is not so great, but Mr. Skeel found that even with these coals the saving was about 7 per cent. of the heat ordinarily wasted. The distribution of the heat developed in the combustion of one pound of the "American Cannel" coal, as determined in the experiments on the two furnaces, shows that the superior economy comes not only from a lesser quantity of combustible matter passing away by the chimney, such as must result from the prevention of smoke, but also from the more perfect combustion going on in the furnace, and the consequent transfer of a greater proportion of that heat to the steam. In the Hoyt furnace the total heat from the fuel, expressed in the equivalent of pounds of steam evaporated from 212, was distributed as follows:

	Pounds.	Per Cent.
In steam evaporated	11·69 =	70·6+
In true products of combustion	3·04 =	18·3+
In combustible matter	0·77 =	4·6+
In heat radiated	1·05 =	6·3+
Total	16·55 =	100·0

With the furnace at the New York Hospital:

	Pounds.	Per Cent.
In steam evaporated	9·56 =	57·8+
In true products of combustion	2·40 =	12·1+
In combustible matter	3·98 =	24 0+
In heat radiated	0·60 =	3·6+
Total	16·54 =	100·0

In the first experiment no smoke was formed, but, during the last, large volumes of black smoke were given off.

Mr. Skeel concludes that, "while for the combustion of *semi-bituminous* coal the Hoyt furnace only offers a single and efficient means for the prevention of smoke, and does not offer any advantage in economy over the ordinary furnace with slow combustion and great skill in firing and only offers an advantage of 7 per cent. over the ordinary furnace with rapid combustion and ordinary firing; yet for the combustion of the highly bituminous coals of the Western States, such as 'American Cannel,' it not only offers an efficient means of *entirely preventing smoke* in the burning of the coals, but renders an increased economy of 13 per cent. over that obtained in the ordinary furnace with very slow combustion and the most skillful firing, and an increased economy of about 30 per cent. over that obtained with rapid combustion and only ordinary skillful firing."

For all stationary uses, therefore, it appears that the furnace is just what has been a long time sought for in such localities as Pittsburgh, St. Louis, and other Western manufacturing cities; and in England, where bituminous coals are so exclusively used, and where the smoke resulting therefrom, as now burned, is so intolerable a nuisance.

J. T. H.

IRON AND STEEL.

INAUGURAL ADDRESS OF DR. C. W. SIEMENS.

[Continued from page 114.]

Processes.—Having thus dwelt—too long, I fear, for your patience—upon the subject of fuel, I now approach the question as to the processes by which we can best accomplish our purpose of converting the crude iron ore into such materials as leave our smelting works and forges. The subject of blast furnace economy has already been so fully discussed by you, during the term of office of your past president, Mr. I. Lowthian Bell, M.P., F.R.S., who has done so much himself to throw light upon the complicated chemical reactions which occur in the blast furnace, that I may be permitted on the present occasion to pass over this question, and to call your attention more particularly to those processes by which iron is made to attain its highest qualities, both as regards power of resistance and ductility. Iron and steel were known to the ancients, and are referred to in their works, but we have no account of the process employed in their manufacture until, comparatively speaking, recent times. Aristotle describes steel as purified iron, and says that it is obtained by re-melting iron several times, and treating it with various fluxes. We are hence led to suppose that in Aristotle's time steel was made by careful selection and treatment of steely iron, which latter was produced by something analogous to the Catalan process. A method referred to by ancient authors is to bury iron in damp ground for some time, and then to heat and hammer it. Another process, described first in Biringuccio's "Pyrotechnology," one of the earliest works on metallurgy, and later in Agricola's "De Re Metallica," both published in the sixteenth century, is to retain malleable iron for some hours in a bath of fused cast iron, when it becomes converted into steel. Reaumur, in 1722, produced steel by melting three parts of cast iron with one part of wrought iron (probably in a small crucible) in a common forge, but he failed to produce steel in this manner upon a working scale. A similar method of producing steel to that proposed by Reaumur has been employed in India for ages, the celebrated Wootz steel being the result of partial or entire fusion of steely iron and carbonaceous matter, in small crucibles arranged in a primitive air furnace, followed by a lengthy exposure of the ingots to heated air in order to effect a partial decarburization. In 1750, Hasenfratz refers, in his "Siderotechnic," to three processes for producing steel: melting broken fragments of steel with suitable fluxes, fusing malleable iron with carbonaceous matter, and so treating cast iron, probably with oxides, as to obtain cast steel directly from it.

First Production of Cast Steel.—The credit of producing cast steel upon a working scale is due to Huntsman, who was the first to accomplish its entire fusion in crucibles, placed amongst the coke of an air furnace, pouring the fluid metal produced into metallic moulds. This process is still carried on largely at Sheffield for the production of steels of special qualities, such as tool steel, tire steel castings and forgings, and a ton of cast steel in ingot is produced with the expenditure of from 2½ to 3 tons of Durham coke, according to the degree of mildness of the metal produced. At Pittsburgh, where pot-melting is employed on a considerable scale, plumbago pots are invariably used of nearly double the capacity of the clay pots used at Sheffield; eighteen or twenty-four of these pots, each containing about a hundredweight of metal, are placed in a furnace, each pot lasting twenty-four hours, and yielding five charges during that interval. The fuel consumed amounts to one ton of small slag per ton of steel melted, and is delivered to the works at the surprisingly low price of 30 cents per ton. With these important advantages in his favor, the American steel melter should be able, one would think, to meet without protection his Sheffield competitor in the open market.

Bessemer Steel.—As regards Bessemer steel, great advances have been made in recent times in cheapening production. At Creusot and other continental works, a system of direct working, or of transferring the pig metal in the molten condition from the blast furnace to the Bessemer converter, has been introduced, and the same method has been recently adopted at several of the leading English works. By this method of working, the fuel usually employed in re-melting the pig metal in the cupola—say 2½ cwt. per ton—is clearly saved; and other advantages are realized; but, on the other hand, the Bessemer converter is made dependent upon the working of the blast furnace both as regards time and the quality of the resulting metal. At Barrow and other large works, where a number of blast furnaces supply a number of Bessemer converters, and pig metal for the open market in addition, this mode of working appears to be practically free from the objection above stated, and a hot ladle, with its engine, may be kept steadily at work transferring the pig metal from one blast furnace or another to the converters. But it still remains to be seen whether any practical advantage can be realized by this method of working at smaller works, where a change in the working of the blast furnace from Bessemer to forge pigs would cause a serious interruption in the working of Bessemer plant.

In America, the effort of the ironmaster has been directed—chiefly under the guidance of Mr. A. L. Holley—towards a saving of labor, by increasing to an almost incredible extent the number of blows per diem from each converter. Thus, I was informed that at the North Chicago Steel Works as many as seventy-three blows had been obtained in one pit in twenty-four hours, although I have reason to doubt whether this rate of working could be maintained for any length of time. The Americans have not adopted, so far as I could ascertain, the direct process of working, but are content to remelt their pig metal in large cupolas in immediate proximity to the converters; the capacity of the converters has latterly been much increased, and the degree of heat engendered by a blast of increased power, has been augmented to such an extent that a considerable amount of scrap metal can be remelted within the fluid bath before discharging the same into the ingot moulds.

Siemens and Martin Steel.—While the Bessemer process has been making rapid strides, a rival process has gradually grown up by its side, which I cannot pass over without remark. I allude to the open hearth steel process, with which my name and the joint names of Siemens and Martin are associated. The conception of this process is really as old as that of cast steel itself. The ancient Indian steel, the Wootz, was the result of a fusion of a mixture of malleable and cast iron. Reaumur, as already stated, proposed to melt wrought iron and pig metal together, for the production of steel, as early as 1722; and G. B. Heath—to whom we owe the important discovery that by the addition of manganese to cast steel its malleability is greatly increased—endeavored to realize the conception of producing steel in large masses upon the open hearth of the furnace in the year 1839, and he again has been followed in these endeavors by Gentle Brown, Richards, and others in the same direction.

The Regenerative Furnace.—When, in 1856, I first seriously gave my attention, in conjunction with my brother, Frederick Siemens, to the construction of a regenerative gas furnace, I perceived that this furnace would be admirably adapted to the production of steel upon the open hearth, and I remember proposing it for such a purpose to Mr. Abraham Darby, of Ebbw Vale, in 1861. Ever since that time I have been engaged in the realization of this idea, which has been retarded, however, by those untoward circumstances which ever intervene between a mere conception and its practical realization. Although two of my earlier licensees, Mr. Charles Attwood, of Tow Law, and the Fourchambault Company, in France, with whom was my late esteemed friend, Mons. Lechatelier, Inspecteur-General des Mines, succeeded, in 1865 and 1866, in producing steel upon the open hearth, they did not persevere sufficiently to attain commercial results; but it was not until after I had established experimental steel works at Birmingham that I was enabled to combat in detail the various difficulties, which at one time looked well nigh insuperable. While thus engaged, Messrs. Pierre and Emile Martin, of Cereuil—who had obtained licenses for furnaces to melt steel both in pots and on the open hearth—succeeded, after a short period of experimenting, in introducing into the market open hearth steel of excellent quality.

While Messrs. Martin thus gave their attention to the production of steel by the dissolution of wrought iron and steel scrap in a bath of pig metal, my own efforts were more especially directed to the production of steel by the use of pig metal and iron ores, either in the raw state or in a more or less reduced condition, which latter process is the one mostly employed in this country.

The Open-Hearth System.—One of the advantages that may be claimed for the open-hearth system consists in its not being dependent upon a limited time for its results. The heat of the furnace is such that the fluid bath of metal, after being reduced to the lowest point of carbonization, may be maintained in that condition for any reasonable length of time, during which samples may be taken and tested, and such additions, either of pig metal, of wrought scrap, spongy metal, or ore, may be made to it as to adjust it to the desired quality. Spiegeleisen, or ferro-manganese, is then added in the solid condition, in the requisite proportion, and the result is a bath of metal, the precise chemical condition of which is known, and which has the advantage, if properly managed, of being what is technically called "dead melted," which circumstance renders it applicable for certain purposes for which pot steel has hitherto been mostly employed.

The purpose for which the open-hearth process is more especially applicable has reference to the conversion of scrap steel and iron of every description into steel or ingot metal, and it is now used, indeed, to a large extent, for the conversion into steel of old iron rails. The wearing qualities of these converted rails have been under test since 1867, when the Great Western Railway Company had some old Dowlais iron rails converted into steel at my experimental steel works at Birmingham, which was rolled into rails by Sir John Brown & Co., and which have been down ever since that time at Paddington, subjected to great wear and tear.

Use of Ferro-Manganese.—The manufacture of steel, both by the Bessemer and the open-hearth process, is much facilitated by the use of ferro-manganese. The material was introduced into the market in 1868, by Mr. Henderson, of Glasgow. It was produced successfully by charging carbonate or oxide of manganese and manganiferous iron ore intimately mixed with carbonaceous matter upon the open hearth of a Siemens furnace with a carbonaceous lining; but the demand for this material was not sufficient to render the manufacture profitable at that time, and it was not until the year 1875 that it was re-introduced into the market by the Terrenoire Company. Manganese, when added in a proportion of ·5 per cent., or more, to steel or ingot metal containing only from ·15 to ·20 per cent. of carbon, has the effect of removing red-shortness, and of making it extremely malleable both in the heated and cold conditions. In using spiegeleisen containing only from 10 to 15 per cent. of metallic manganese, it is impossible to supply the amount necessary to produce this malleability without adding, at the same time, such a percentage of carbon as would produce a hard metal. The use of ferro-manganese enables us to overcome this difficulty, and greatly facilitates the production of a metal so malleable and with so little carbon as to remain practically unaffected in its temper when plunged red-hot into water.

Another result produced by the use of manganese without carbon, upon mild steel or ingot metal, is to neutralize the objectionable effect of phosphorus, so long as the latter does not exceed the limit of ·25 per cent. This metal, in which phosphorus may be said to take the place of carbon, presents a large specular fracture, and is, contrary to what might have been expected, extremely ductile when cold. Iron when in the fluid condition can be alloyed with other metals, and some of the compounds thus formed are known to possess very remarkable properties.

Tungsten.—Thus, iron combined with 3 per cent. of tungsten and ·8 per cent. of carbon, yields a metal which can be worked like ordinary steel, but which, when hardened, retains magnetism to a very remarkable degree. A further addition of tungsten produces an exceedingly hard metal (introduced into the market by Mr. Mushet) which cannot be forged, but which, when cast into bars and ground so as to form a sharp edge, produces cutting tools capable of great endurance.

Chromium.—An admixture of chromium has for many years past been known to produce steel of great hardness and strength, but it is only quite recently that it has been brought into practical use in America by Mr. Julius Baur, and has been taken up in this country by Sir John Brown & Co., of Sheffield, who claim for it very remarkable properties as regards strength, malleability, and freedom from corrosion. The formation of compounds such as these is a matter of great interest in connection with the future development of the applications of steel, and is one of those subjects which I venture to suggest might be much advanced by an organized research, under the auspices of a committee of the Iron and Steel Institute.

Mild Steel.—The value of the material known as mild steel or ingot metal consists in its extreme ductility under all possible conditions. Its ultimate strength is much inferior to that of ordinary steel, and rarely exceeds 28 tons per square inch; its limit of elasticity is reached at 15 tons per square inch; while the limit of elasticity of a harder steel may reach from 25 to 30 tons per square inch, and that of hard drawn steel wire from 45 to 50 tons. But in estimating the relative value of these different materials by the amount of work that has to be expended in causing rupture, it will be found that the mild steel has the advantage over its competitors. When subjected to blows or sudden strains, such as are produced by the explosion of gun cotton or dynamite, extra mild steel differs in its behavior from that of BB iron and ordinary steel, by yielding to an extraordinary extent without fracturing, and it is in consequence of this non-liability to rupture that it may be loaded to a point much nearer to its limit of elasticity than would be safe with any other material.

The Piping of Steel.—Attention has been recently directed in various quarters to remedy a defect appertaining to steel, that of piping and showing honeycombed appearances in the ingot. It is well known that if such steel is hammered and rolled, the open spaces contained in it are elongated and seemingly closed up, but in reality continue to form severances within the metallic mass, to the prejudice of the uniform strength of the finished forging. In casting steel containing more than 0·5 per cent. of carbon, the defect of honeycombing can easily be avoided if care is taken to have the metal "dead melted" before casting it into the mould; and that of piping in continuing the inflow of fluid metal for a sufficient length while it is setting. But in dealing with mild steel containing only say 0·2 per cent. of carbon, the difficulty of making a sound casting is greatly increased. Much may be done, however, by careful manipulation of the fluid metal, and by the judicious addition to it of manganese or other oxidizable metal, such as silicon or lead, by which occluded oxygen is removed. Sir Joseph Whitworth, who, as you well know, has given much attention to this subject, has overcome the evil mechanically by subjecting the steel while setting in the mould to great hydraulic compression. He has thus succeeded in producing, in large masses, mild steel of extremely uniform strength, and the only doubt which could possibly be raised against the advisability of producing fluid steel for ordinary applications by this method is on the question of expense. The subject of producing sound steel castings is one which we shall have an opportunity to discuss in reference to a paper which will be presented by M. Gautier.

Applications of Steel.—The employment of steel for general engineering purposes dates only from the year 1851, when Krupp, of Essen, astonished the world by his exhibits of a steel ingot weighing 2,500 lbs., and of his first steel gun, and introduced a comparatively mild description of pot steel for steel tires, axles, and crank shafts. For the production of these he constructed his celebrated monster hammer, with a falling weight of 45 tons, which at that time far surpassed in magnitude and power our boldest conception, and is now only being exceeded by a still more powerful hammer in course of erection at Essen Works.

Krupp's steel was, however, not cheap steel, and it is to our past president, Mr. Henry Bessemer, that we are indebted for the production of steel at such a reduced cost as to make it available for railway bars and structural purposes in substitution for iron, since which event the applications of this superior material show a most extraordinary rate of increase.

Not only do we travel upon steel tires, running over steel

rails, but at least one of our leading railway companies, the London and Northwestern, has, under the able management of Mr. F. W. Webb, constructed as many as 748 locomotive engines, including boiler, frame, and working parts, entirely of that material, excepting only the fire-boxes, which are still made of copper.

In France, also, much attention has been given to the introduction of steel for machinery purposes, and there, as well as in the United States, Germany, and Holland, that material is used largely in the construction of bridges and other engineering works. In this country the application of steel for structural purposes has occupied the attention of some of our leading civil engineers for many years, and Sir John Hawkshaw, when called upon to construct a railway bridge at Hungerford, in 1859, proposed the use of steel in order to lighten the structure. He was prevented, however, from carrying his idea into effect by the rules of the Board of Trade, which provide that any kind of wrought material shall not be weighted either in compression or extension to more than 5 tons per square inch. Repeated efforts have been made since that time to induce the Board of Trade to adopt a new rule, in which the superior strength of steel should be recognized; and in order to facilitate their action, a committee was formed, consisting of Mr. William Henry Barlow, Captain Galton, and others, who carried out—with the pecuniary aid of leading steel manufacturers—a series of valuable experiments, showing the limit of elasticity and ultimate strength of various steels, which results are published separately in the "Experiments on the Mechanical and other Properties of Steel by a Committee of Civil Engineers." At the instance of Mr. Barlow, the British Association appointed a further committee to promote the object of obtaining for steel its proper recognition, and this has led finally to the appointment, under the sanction of the Board of Trade, of three gentlemen, viz., Sir John Hawkshaw, F.R.S., and Mr. William Henry Barlow, F.R.S., who were nominated by the Council of the Institution of Civil Engineers, and of Colonel Yolland, F.R.S., of the Board of Trade. These gentlemen have agreed upon a report recommending the use of steel as a building material, subject to a limit of strength greatly in excess of the limit assigned to wrought iron; and it is to be hoped that the Board of Trade, by adopting that report, will remove the serious drawback which has too long stood in the way of the application of steel for structural purposes, and which has rendered the construction of large works, such as the projected bridge over the Firth of Forth, practically impossible.

As regards the construction of ships of extra mild steel, the English Admiralty, following the example set by France, has, under the able advice of Mr. Barnaby, the Chief Constructor, taken the lead of the commercial navy of the country, and several corvettes have recently been constructed entirely of that material at the Government yard at Pembroke, and upon the Clyde. The constructors of merchant shipping have been hitherto restricted by rules laid down by Lloyd's Registry, which make no distinction between common iron and steel in determining the classification of a vessel. It is to be hoped that the engineering and shipbuilding interests of the country will soon be released from regulations which may have been well adapted to the use of an inferior material such as common iron, but fail entirely to meet the requirements of the present day. In shipbuilding, the use of a material superior in toughness and in strength produces the double advantage of greater safety to life and property, and of an increase of carrying capacity to the full amount of weight saved in the construction of the ship. It should be borne in mind that this additional weight of merchandise is carried without increasing the working expenses and power required to propel the ship, and may just suffice to strike the balance between working a vessel designed for long voyages at a fair profit or a loss. In constructing the masts and yards of vessels of the stronger material, the weight saved is a matter of still greater importance, which I am glad to say now engages earnest attention.

In the United States, a committee, composed of both military and civil engineers, have been engaged for some time upon the subject of determining experimentally the structural value of iron and steel, with the advantage of substantial support from the United States Government, who, after a previous grant of $75,000, have, I observe, granted a further sum of $10,000 in aid of the experimental inquiries instituted by the committee. The council of the Iron and Steel Institute are not unmindful of the importance of this subject, and have invited those gentlemen of this and other countries, who have given most attention to the production and application of steel, to aid us in our forthcoming discussion with the results of their experience. In the course of this discussion the distinctive limits between steel and iron will necessarily engage your attention.

Nomenclature.—Considering the extraordinary change of physical condition which iron undergoes when alloyed with small percentages of carbon, manganese, phosphorus, tungsten, chromium, and other substances, and considering further, that it is never quite free from some admixture, the question of nomenclature is one naturally surrounded with difficulty, but it is becoming one of considerable practical importance when rules are to be laid down regulating the permissible strength of different grades of these materials. Dr. Perry has, in his "Metallurgy of Iron and Steel," defined steel as iron containing a small percentage of carbon, the alloy having the property of taking a temper; and this definition is substantially equivalent to those found in the works of Karsten, Wedding, Grüner, and Tunner. On the other hand, Messrs. Jordan, Greiner, Gautier, Phillipart, Holley, and others define as steel alloys of iron which have been cast in malleable masses, while Sir Joseph Whitworth considers that steel should be defined mechanically by a coefficient representing the sum of its strength and ductility. With the object of settling this question of nomenclature, an International Committe was appointed at Philadelphia by the Institute of American Mining Engineers. The committee consisted of the following gentlemen: Mr. I. Lowthian Bell, M.P.; Dr. Hermann Wedding; Professor Tunner; Professor Akermann; M. Grüner, and Messrs. A. L. Holley and T. Egleston, and they resolved that the following should be recommended:

1. That all malleable compounds of iron, with its ordinary ingredients, which are aggregated from pasty masses, or from piles, or from any form of iron not in a fluid state, and which will not sensibly harden and temper, and which generally resemble what is called wrought iron, shall be called weld iron (German, *Schweisseisen;* French, *fer soude*). 2. That such compounds when they will from any cause harden and temper, and which resembles what is now called "puddled steel," shall be called weld steel (German, *Schweiss-stahl;* French, *acier soude*). 3. That all compounds of iron, with its ordinary ingredients, which have been cast from a fluid state into malleable masses, and which will not sensibly harden by being quenched in water while at a red heat, shall be called ingot iron (German, *Flusseisen;* French, *fer fondu*). 4. That all such compounds, when they shall from any cause so harden, shall be called ingot steel (German, *Fluss stahl;* French, *acier fondu*)." The nomenclature here proposed is entitled to careful consideration from the eminence for both theoretical and practical knowledge of the gentlemen composing the committee; but I apprehend that for common use the distinctions desired to be drawn are too manifold. Moreover, the lines of demarkation laid down run through materials very similar, if not identical, in their application, where a distinction in name would be extremely difficult to maintain and awkward to draw. Take, for instance, railway bars from ingot metal, which are usually specified to bear a given dead load without deflecting beyond certain limits, and to resist a certain impact without rupture. The materials answering to these requirements contain from ·2 to ·6 per cent. of carbon, depending in a great measure upon the mode of production, and upon the amount of admixture of phosphorus, sulphur, silicon, and manganese. But inasmuch as the quality of tempering depends chiefly upon carbon, part of the rails delivered under such specification might have been classified as ingot iron, and part as ingot steel. The committee omits to define the degree of hardening which it considers necessary to bring a material within the denomination of ingot steel. It is well known, however, that the temper depends upon the exact temperature to which the metal is heated before being plunged into the refrigerating medium, and also upon the temperature and conductivity of the latter, and that ingot metal, with even ·2 per cent. of carbon, when plunged hot into cold water, takes a certain amount of temper. The question of the amount of import duties payable in foreign countries upon metal occupying a position near the proposed boundary line, would also lead to considerable inconvenience. Difficulties such as these have hitherto prevented the adoption of any of the proposed nomenclatures, and have decided engineers and manufacturers, in the meantime, to include, under the general denomination of cast steel, all compounds consisting chiefly of iron, which have been produced through fusion, and are malleable. Such a general definition does not exclude from the denomination of steel, materials that may not have been produced by fusion, and which may be capable of tempering, such as shear steel, blister steel, and puddled steel, nor does it interfere with distinctions between cast steels produced by different methods, such as pot steel, Bessemer steel, or steel by fusion on the open hearth. The forthcoming discussion will, I hope, lead to some general agreement regarding this question of nomenclature.

Wrought Iron.—While steel is gradually supplanting wrought iron in many of its applications, efforts are being made to maintain for the latter material an independent position, for cheapness and facility of manipulation, by improving the puddling process.

Mechanical Puddling, like many other important inventions, has taken a long time for its development, and has engaged the attention of many minds, but I will only here mention the names of Tooth, Yates, and Mr. Menelaus, our past president, who have pioneered the road; and of Danks, Spencer, Crampton, and others who have followed more recently in the same direction. It is chiefly owing, however, to the persevering endeavors of Mr. Heath, and of Messrs. Hopkins, Gilkes & Co., that the mechanical puddling of pig metal has been accomplished with a considerable amount of success. All these efforts have had reference to puddling in a chamber rotating upon a horizontal axis, but numerous attempts have also been made to accomplish mechanical puddling by the introduction into stationary chambers of rabbles moved by mechanical power, and by the use of chambers rotating upon an inclined axis, in connection with which latter the names of Maudslay, Sir John Alleyne, and Pernot should be mentioned. The principal difficulty connected with the rotary puddling furnace consisted in providing a lining of sufficient power to resist the corrosive action produced by siliceous slags, and it is important, therefore, that the pig metal introduced into the rotative puddler should be as free from silica as possible. By charging fluid metal into the furnace, the silica adhering to the pigs in the form of sand is got rid of; but efforts have latterly been made, with satisfactory results, I believe, to subject the pig iron itself to a simple finery process on its way from the blast furnace to the rotative puddler, with a view of removing the silicon chemically combined with the pig. M. Hamoir, of Belgium, has been engaged upon this subject for some years, as you will have seen from the "Report on the Progress of the Iron and Steel Industries in Foreign Countries" in our "Journal;" while in this country, Mr. I. Lowthian Bell has called the Bessemer converter into requisition for effecting the desired object.

Bell's New Process.—We are informed that not only does the lining of the furnace stand better in using this semi-refined metal, but that the yield per furnace per diem, as well as the quality of the metal obtained, are much improved. It is intended to roll the metal thus produced into railway bars, without any intermediate process of re heating, and to subject the rails to a process of case-hardening similar to what was practised some years ago by Mr. Dodds, in South Wales. The case-hardened iron rails are expected to rival steel rails in quality, but it remains to be seen whether these wearing properties are not obtained at the cost of brittleness, and whether rails manufactured by this method can compete in price with steel rails.

Wrought Iron direct from the Ore.—Three years ago, I had the honor of bringing before this Institute a plan of producing wrought iron directly from the ore, in a rotative furnace of special construction, and heated by gas. This process was at that time only carried on upon a small scale at my sample steel works, in Birmingham. It has since been carried out upon a working scale, at Towcester and in Canada, and although the results hitherto obtained cannot yet be considered entirely satisfactory from a commercial point of view, I see no reason to feel discouraged as regards the ultimate result of this method of treating iron ores. By it, iron of almost entire freedom from sulphur and phosphorus is obtained from ores containing a considerable percentage of these impurities. If steel is to be produced, the raw balls, as they leave the rotary furnace, are either immediately transferred to the bath of the open hearth furnace, or are previously subjected to the processes of squeezing and hammering for the removal of scoria, which otherwise carries some of the impurities contained in the ore into the metallic bath, and prevents the attainment of steel of a high quality.

Protection of Iron and Steel from Rust.—One of the drawbacks to iron and steel for structural purposes is found in their liability to rust when exposed to air and moisture. The ordinary means of protection against rust consists in covering the exposed surfaces with paint, and, if this is renewed from time to time, iron and steel may be indefinitely preserved from corrosive action. Another mode of protection consists in dipping articles of iron and steel while hot into a bath of oil, when some of the oil penetrates to a slight depth into the pores of the metal, while other portions become decomposed, and form a very tenacious resinous coating. For the protection of iron and steel, when in the form of thin sheets or wire, galvanizing, as is well known, is largely resorted to. The principle of protection in this case depends upon the fact that zinc, although more oxidizable than iron, forms, with oxygen, an oxide of a very permanent nature which continues to adhere closely to the metal, and thus prevents further access of oxygen to the same. This mode of protection presents the further advantage that so long as any metallic zinc remains in contact with the iron in presence of moisture, the latter metal forms with the zinc the negative element of an electrolytic couple, and is thus rendered incapable of combining with oxygen. Galvanizing is not applicable in those cases in which structures of iron and steel are put together by the aid of heat, or are brought into contact with sea water, which would soon dissolve the protecting zinc covering. But even in these cases the metal may be effectually protected against corrosion by attaching to it pieces of zinc, which latter are found to dissolve in lieu of the iron, and must, therefore, be renewed from time to time.

Ainslie's Method.—Captain Ainslie, of the Admiralty, has lately made a series of valuable experiments, showing the relative tendency towards corrosion of both iron and steel when in contact with sea water, and of the efficacy of pieces of zinc in preventing this corrosion. These experiments further show that mild steel is—contrary to the results obtained by M. Gautier—more liable to corrosion than wrought iron in its unprotected condition, but that zinc acts most efficaciously in protecting it.

Barff's Method.—Quite recently, another mode of protecting iron and steel plates from corrosion has been suggested by Professor Barff. This consists in exposing the metallic surfaces, while heated to redness, to the action of superheated steam, thus producing upon their surface the magnetic oxide of iron, which, unlike common rust, possesses the characteristic of permanency, and adheres closely to the metallic surface below. In this respect it is analogous to zinc oxide adhering to and protecting metallic zinc, with this further advantage in its favor, that the magnetic oxide is practically insoluble in sea water and other weak saline solutions.

Before concluding this address, I wish to call your attention to a matter which will require your early consideration. The Iron and Steel Institute has now attained an influential position, and is likely to increase from year to year in its beneficial action upon the further development of a trade which may justly be claimed to be the most important in the country. In order to give additional weight to its action, it seems necessary that its position should be recognized in official quarters, and that it should be possessed of a habitation, in a central locality, which should comprise office accommodation, a library, a model room, a lecture room, and laboratory. Such a building, if specially erected for the Iron and Steel Institute, would exceed the means at their disposal for such a purpose, but the moment has arrived when other institutions devoted to the cultivation of different branches of applied science feel the necessity for similar accommodation. Would it not be possible for our Institute to join efforts with those kindred institutions for the erection of a joint building representing applied science of the country as completely as Burlington House represents pure science. Such a project could not be realized without the concurrence of the parent institution of applied science, "The Institution of Civil Engineers," whose building, though large, is by no means sufficient for its actual requirements. The new building might, therefore, accommodate the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects, the Society of Telegraph Engineers, the Iron and Steel Institute, and possibly other societies which hold their ordinary meetings on different days of the week, and some of them at considerable intervals of time; it would not, therefore, be necessary to provide more than one, or, perhaps, two, general meeting rooms, and one library, but each society would require separate office accommodation and council chambers, the whole being so arranged as to be able to be thrown open for the holding of *conversaziones.* The common interests of the societies might be placed under the supervision of a joint House and Library Committee, presided over by the President of the Institution of Civil Engineers, and comprising amongst its members one or two members of councils and the secretaries of the different societies. The Government would not probably be unwilling to further the realization of an object of such great usefulness by granting a site in a central portion of the metropolis. Each society might be called upon to furnish a portion of the capital required, either out of its accumulated funds or by voluntary contributions of its members, and the remainder could probably be raised upon debentures, and thus become chargeable upon the ordinary subscriptions of future years. The details of such a scheme would, of course, require most careful consideration; but I believe that the present moment would be favorable for its realization, if you, as well as the other scientific bodies considered, consider the matter worthy your attention. The great variety and importance of the subjects of interest to our Institution are my apology for having detained you longer than I intended in reading this address.

STEEL MAKING.

By the process, H. Larkin, of Manchester, instead of the routine of smelting, puddling, rolling, and converting into blister steel, the ore, which is mainly obtained from the Marbella Mines, in Spain, is crushed and reduced to as fine a condition as possible, and the after-processes are of such a nature that the whole may be described as the manufacture of steel direct from the ore. For the purpose of separating the pure oxide of iron from the gangue, or dross, of the ore, an ingeniously-constructed machine is employed, which, by means of a series of magnets, removes the grains of metal from the refuse. A comparatively pure magnetic oxide of iron having thus been obtained in the form of sand, it is mixed with a sufficient quantity of carbonaceous matter to absorb the oxygen combined with the metal, and so to effect its reduction. Powdered charcoal and resin, or other bituminous matters, are mixed with the iron-sand, and the mixture is compressed into blocks, which are placed in a furnace, consisting of a series of ordinary D-shaped retorts, so set in an intricate arrangement of bricks that nearly all the heat of the fuel is utilized. The retorts having been filled with the compressed blocks, an operation which is very quickly performed, a full red heat is kept up for about twenty-four hours, when, the carbonaceous matter having been practically consumed, the ore is left in the state of a red-hot iron powder. The difficulty is now to get this powder out of the retorts, for it is important that it should be kept as much as possible from the contact of atmospheric air, the oxygen of which would be readily seized by the iron, to the destruction of the latter, so far as the process is concerned. This difficulty has been effectually overcome by filling the retorts

with coal-gas, which consists almost wholly of carbon and hydrogen. A receiver is placed at one end of a retort, and, while a full pressure of gas is kept up, the door at the other end of the retort is replaced by one with a slot, or hole, through which an iron tool is introduced, and the charge is quickly pushed into the receiver, which is then removed and kept tightly closed until the iron powder is cold, when it can be exposed to the air without damage. Thus far the process is complete. The pure metallic iron is then mixed with carbonaceous matter, such as resin, and is pressed into cakes, which are melted in the usual way in crucibles with manganese, chromium, or any other metal which it may be desired to add. It will be seen that it is scarcely correct to speak of the process as one for making steel direct from the ore, but it is still sufficiently direct to have a fair claim to the title. It remains only to say that tools made from this steel have accomplished double and treble the work done by the best tools hitherto employed; and its success will, it is to be hoped, be an encouragement to others to persevere in other branches, and retain for us our pre-eminence in the "iron trade."—*London Echo.*

IRON AS A BUILDING MATERIAL.

THERE are two sides to every question: and as the reasons in favor of iron as a building material have been stated and re-stated pretty frequently in modern times, it is desirable now and then to remind architects, and still more the general public, of the reasons against it. Professor Barry, in his first lecture this year at the Royal Academy, has referred to the subject, and has advocated, though in a cautious and sober way, the use of iron architecturally; or, in other words, the treatment of structural ironwork on artistic principles. This is very proper advice to give to engineers, or to architects who may have to do engineering work in large railway stations, and the like. It is, we think, dangerous advice to give to those who have to do with street architecture, and with public and domestic buildings generally.

Architectural and engineering works, taking them in the mass, differ in one most important point: the former are in constant danger of fire, while the latter are not. An iron bridge is safe from fire; there is nothing combustible about it. An iron railway station (not a goods shed) is almost equally safe, if it is a large one—since the combustibles likely to be found in it are small in quantity compared to its size.

NOTHING BURNS DOWN AS FAST AS AN IRON "FIREPROOF" BUILDING.

It is altogether different with the combustible part of a house, a warehouse, or a theatre; and in many such buildings there is a great deal too much structural ironwork used already. Nothing burns down so fast as a building carried on cast-iron columns; witness the Surrey Music Hall, destroyed in half an hour. Nothing is so dangerous to firemen as what is fondly named "fireproof construction," and the reason is that it depends—in almost every case—on iron girders and rolled joists. It is easy enough to make a building fireproof, where small spans are allowable, and where, as in places for storage, piers are not in the way; but the system is too old to be patented, and so nobody has an interest in advertising it. All that is necessary is to have solid brick walls, brick piers, and brick vaults—and to avoid ironwork as you would gunpowder.

CAST-IRON AND WROUGHT-IRON UNDER FIRE.

Every one knows that of the two, cast-iron yields to fire even sooner than wrought-iron. It loses a considerable percentage of its strength at about 200 degrees, and when red hot will not carry its own weight. The iron columns at the Surrey Hall, where not melted, were bent into all kinds of fantastic shapes, and twisted, some of them, like corkscrews. Wrought-iron, on the contrary, retains a good deal of its strength at a red heat; but a red heat is nothing compared to the temperature of a building in a great fire.

WOODEN BEAMS SAFER THAN IRON.

Neither wrought nor cast iron is worth anything in this situation; and we have Captain Shaw's assurance that he would rather trust a stout wooden beam in a fire than any iron girder that ever was invented. One of the first duties of an architect, especially in towns, is to provide against fires; and his next duty is surely to make fires, if they happen, as little dangerous to life as possible.

IRON BEAMS AND GIRDERS REQUIRE SPECIAL PROTECTION.

The use of iron in the form of girders and columns is well known to increase their danger greatly; the more weight that is put on it, the more deadly it is. The only remedy known is to cover it up with something that is really fireproof—such as brick, concrete, or plaster; and then what becomes of the everlasting cry that architects should treat iron artistically? The architect's first duty is to imbed it as deep as he possibly can in a different material, and not to show a particle of it, as a main structural feature, either inside or outside of his building. He may need to study the artistic treatment of this necessarily concealed construction; but this is quite a different thing from studying the artistic treatment of ironwork.

AN INCOMBUSTIBLE BUILDING NOT NECESSARILY FIREPROOF.

Some day we may hope that a new Metropolitan Buildings Act will be passed, and that its framer will be clear-headed enough to see—what few of the general public do see at present—that to be incombustible is not necessarily to be fireproof. In that case we may be sure that provision will have to be made for imbedding or thoroughly casing with brick or plaster all the iron columns and girders that can possibly be so treated.

IRON MUST BE PUT OUT OF SIGHT.

The first thing, then, that an architect has to do with iron as a building material is to put it out of sight; and, in many cases, to do this so thoroughly that even its shape and general outline will no longer be discernible. His iron columns he may surround with brick or concrete so that they appear as columns still, though not as iron ones; but his iron girders will be safest buried in the very midst of his concrete floor. And even then neither columns nor girders will be anything like safe. Iron is so rapid a conductor of heat, that if only a few bricks fly off with the fire, or a few square feet of concrete crack and come down, both columns and girders will rapidly get hot, lose their strength, and come down in a heap of ruins. Still one must risk something; and, as wrought-iron joists are very convenient, this amount of danger is not likely to put them entirely out of use. Cast-iron columns are more objectionable, even when encased; and rolled-iron stancheons, riveted into a + or other strong section, might well be substituted for them. But, in any case, the net result is, that in the great mass of the buildings with which an architect is concerned, he will have few opportunities, however much he may desire them, of trying his skill on the artistic treatment of iron as a building material. If he does so, he will do it, more or less, at the general peril, in case of fire; and he ought, except in certain quite exceptional cases, to be prevented by law from doing it at all. The exceptional cases are those in which fire is not to be feared. There is, first, the class provided for in the present act, in which a shed or other uninhabited building, may be made of combustible materials if it stands far enough away from all other property. Iron might, of course, be exposed to view in a building of this sort, as it now is; but then there is not much scope for artistic design in the ironwork any more than in the woodwork of a shed. It is not here, probably, that architects will be able to follow the enthusiastic advice so often given to them, to take up this neglected material and make it vie in effect with marble in the hands of the Greeks, or with stone in those of the mediæval builders. There remains, then, only the other class, to which the structure either has nothing combustible about it, or in which the quantity of combustible material is too small to do much harm in the event of fire.

CLASSIC ARCHITECTURE.

The first thing that will occur to every one as to this class of work is, that it is mainly in the hands of engineers. It is of little use to admonish architects as to the way in which they ought to deal with a description of building which, as a matter of fact, they never have to design. We shall, doubtless, be told, and with some truth, that they ought to design it, and that if they had been equal to the wants of the times some forty or fifty years ago, they still would have done so. Very possibly this may be the case; but we have to deal with the present day, and not with the earlier part of the century. At that time, the classic school, whose praises Mr. Bentinck has just been sounding, formed almost the entire profession; and they were so busily engaged in imitating, as he tells us, the "finest works of the best masters," that they had no time to think about the new and pressing problems of the age they lived in. Besides, the best masters of the classic school did not build in iron, and their works could not even be copied in it, though they might in stucco. Their disciples, therefore, patronized the plasterer, and let the iron-founder and the iron-roller find employment as they could. This was how work of this kind got into the hands of the engineer; and though since the happy "Decline and Fall of (so-called) Classic Architecture," a multitude of architects have adopted a sounder system, it cannot be expected that such work will immediately come back. The specialist custom, too, has arisen—less by the wish of architects than by the choice of the public, who cannot believe that any man can be eminent in more than one narrow department of his own profession: and, by this time, if no separate class of engineers existed, the architects who would have done engineering work would have been, in practice, quite distinct from those who do warehouses, churches, or houses. Still, however, they might have had an architectural training; and if they had been trained in any genuine architectural style—that is, in almost any except the "Classic" of our predecessors, they would have dealt with iron more economically and far more artistically than the engineers have done. A man with artistic habits has the ambition of doing things in a pleasing way; but a coarse, merely practical man has no ambition above that of making the vulgar stare; and this ambition is far more costly than the other. The money that has been spent by engineers in trying to build roofs and bridges of wider spans than other engineers—where wide spans had no real advantage—would have made all the ironwork of our railway stations artistic. By artistic, we mean pleasing in form, truthful, and reasonable; not ugly in form, and plastered over with a quantity of trashy ornament, like the Ludgate-hill railway bridge, for example.

The conclusion from this head seems to be that there is room, and, indeed, real need for a link between the two professions, in the shape of architectural engineers; engineers who shall be able to design as well as to calculate; architects who shall be able to build in iron on a large scale as well as in brick or stone. So far, Professor Barry's advice is very good for any one, whether architect or engineer, who has, or may have, the designing of railway stations, railway bridges, or other works of the same class. The point we insist upon is, that there is a vital and fundamental distinction between this class of work and all others; and that it is in this class alone that there is scope—if questions of practical safety have any weight—for the artistic design of structural ironwork. In this class of work the ironwork is visible; in all other classes it ought to be imbedded as deep as it can possibly be in brickwork or concrete. It is true that this is seldom done at present; but this, rather than the making iron ornamental, is the true end to aim at in the ironwork of public buildings and town architecture generally; and this, whenever the Metropolitan Building Act is revised and freed from its present absurdities, will, doubtless, become, to a large extent, imperative in London.

IRON STRUCTURES NOT DURABLE.

Suppose, however, that this end is attained, and that structural ironwork is everywhere safe from fire, we have still some very serious faults to find with it. How long will it last, and how much of a building, in which iron is freely used, will remain when the iron fails? How many of our "great engineering triumphs" in iron construction will outlast the next century? When the Romans built a bridge or a viaduct, the thing *was* built; it lasted, with fair play, for ten or twenty centuries, and may yet last as many more. When the modern engineer puts an iron tube, or a pair of lattice girders across a stream, all he has done is to find a temporary expedient for spanning it, which Nature, as if in scorn of its clumsiness, hastens to destroy. Every shower of rain takes something from its strength in the shape of rust; every passing train helps to make it more and more brittle by vibration. The time will not be long before all these iron bridges fail, and before the short-sighted policy which erected them will be a derision and a proverb of reproach.

IRON WORKS DESTROYED BY RUST.

We forget how many tons of rust were scraped off the Menai Bridge some five years after its construction, but enough to show that with the greatest care it could hardly outlast a century. If this happened with so important a work only recently completed, we may judge what the case must be with other iron structures, longer built and more neglected.

Six and twenty years ago, as many of us recollect pretty clearly, there was an universal flourish of trumpets over the new style that had been invented. Architects, we were told, were superseded; bricks and mortar had had their day; a new nineteenth century style of iron and glass had arisen, and Paxton was its prophet. The daily papers were in raptures, and predicted the universal advent of the greenhouse dispensation. The Sydenham Crystal Palace sprang up; its history has been a history of rust and breakages; its shareholders' profits have gone in vainly trying to keep it weather-proof; and its present state is such that, within the last few days, it has been publicly proposed to pull it down and build houses over the site. So much for iron buildings. Is it not likely that the same kind of failure will happen, if a little more slowly, to iron roofs? They are protected, it will be said, by painting; so was the Crystal Palace, with more care, probably, than most iron roofs receive. Painting, too, is liable to be neglected; in the long run, is sure to be sometimes neglected—through oversights, through want of money, or through the desire of the managers of a company to show a larger margin of profit than they fairly can. The damage to a wrought-iron structure of one such period of neglect may be irremediable; and, even when there is no neglect, iron may go on rusting, under certain conditions, after it is painted. Whatever is done, rivets and rivet-holes cannot be painted where they are in contact; and so the most important part of the work necessarily becomes the most unprotected.

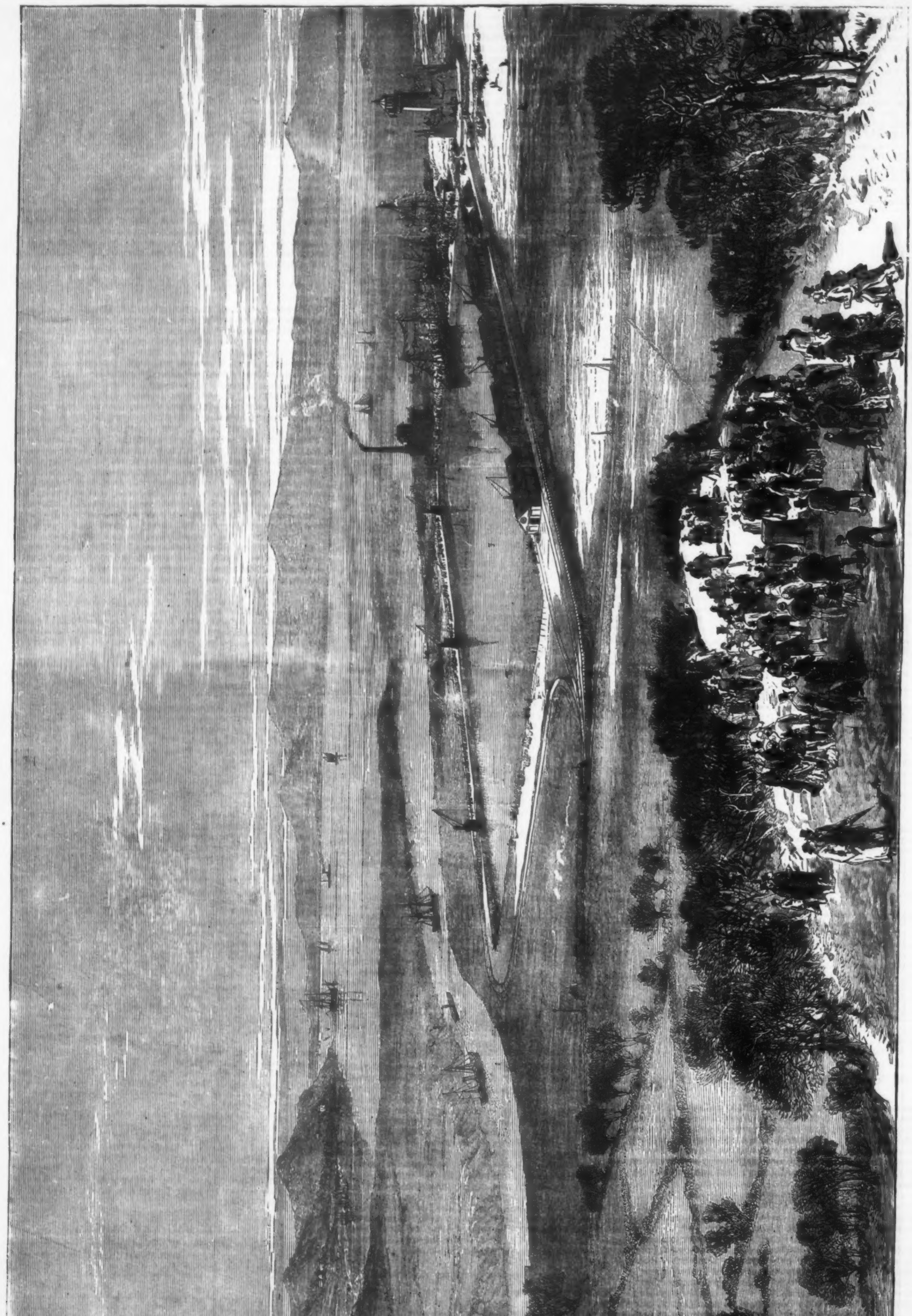
WEAKENING EFFECT OF VIBRATION, EXPANSION, AND CONTRACTION.

We have only hinted at the effects of vibration on iron, because the rate at which wrought-iron becomes brittle and crystalline under its influence has not been fully investigated. It may, or it may not, ultimately become a general source of weakness in iron structures. If it does, it will be a very serious one, because it will lead to sudden and not to gradual failures. We have said nothing, either, of the effect which the expansion and contraction of great masses of iron are sure to have, in time, upon masonry and brickwork; not so much in bridge-work, where the abutments are practically immovable, as in wide span buildings, where the walls are thin. There must be, in fact, a continual rocking backwards and forwards of the brickwork—to a very small extent, indeed, but by a perfectly irresistible force—as the metal contracts and expands. The result of the whole will be that by the time the iron roof has rusted into a dangerous state, the brickwork and masonry will have been so pushed and pulled about that they will be about as worthless as the roof; and so the whole thing will come to an end together. In the words of Dr. Mackay's once popular song, "We may not live to see the day, but there's a good time coming." London railway bridges, and London railway stations will not last very long; their "anti-human" ugliness is a nuisance which Nature kindly hastens to do away with; and their only use, in some five or six generations, will be to raise a laugh at the trumpery engineering of the nineteenth century.—*Building News.*

TEMPERING SPRING AND TOOL STEEL.—If steel is heated to redness and allowed to cool slowly, it becomes nearly as soft as pig iron, and can be as readily worked. If, however, when so heated it is suddenly cooled, as by plunging it into water, it becomes very hard and brittle. Between these two extremities almost any degree of hardness may be given steel, and in diminishing its hardness to the point that has been shown to be the best for certain uses consists the art of tempering. With the explanation that seems almost unnecessary, that in tempering the steel is made very hard, and then its hardness reduced by heating it to a certain point indicated by the color of the steel, or, if heated in oil, by the color of the smoke or by flame, we give some rules to be observed in tempering: 1. The steel should be very hard before tempering. If the articles to be tempered are not properly hardened at first, it will be time and labor lost to temper them. 2. The heat for tempering should not be too suddenly applied. The slower the heating the tougher and stronger the steel. 3. The most careful and experienced workman is liable to be deceived in the color of the steel, and consequently in the temperature in an imperfect light or at twilight. 4. Where water is used for plunging the steel in, the less frequently it is changed the better, provided it does not get greasy. The temperature to which the steel should be raised for various purposes is shown by the color of the steel when heated. Lancets, which must be very hard, in order that they may be ground to a keen edge, are tempered to the faint yellow tinge, equal to 430° Fah.; while razors and surgical knives, which must be less easily broken, are tempered to the straw yellow, equal to 450° Fah. Penknives are tempered upon an iron plate over the fire, the blades being laid upon it on their backs until they have acquired the full yellow color, equal to 470° Fah. Cold chisels and large shears for cutting iron must stand rougher usage, and are therefore tempered to a brown yellow, equal to 490° Fah.; while the brown with purple spots, equal to 510° Fah., marks the tempering heat for axes and plane irons. Table knives are heated till they acquire a purple color, equal to 530° Fah., in order to let them down to a proper temper; and articles in which great elasticity is required, such as swords and watch springs, are tempered to a bright blue, equal to 550° Fah.; while saws are brought to the highest tempering heat at which the dark blue color shows itself. This temperature, about 600° Fah., is that at which oil boils and inflames, so that a bath of oil is very frequently used in tempering, the articles being immersed in it and the temperature ascertained either by a thermometer or by the volume and color of the smoke which rises from the oil. Some tools are annealed by plunging them into oil heated to 400° Fah., and allowing them to cool down in it. Small steel tools, after being hardened by chilling in water, are coated with tallow, heated over a flame till the tallow begins to smoke, and then stuck into cold tallow. Large steel implements are let down to the proper temper by being heated in a kind of oven known as a muffle.—*Iron.*

IRON RAILWAY CARS.

THE Minister of Public Works of Belgium announces that the State Railways were about to put in hand 800 carriages. The *Moniteur des Interets Materiels* is very urgent in recommending that they be built of iron, at least in part. "Cars with sheet iron bottoms have long since been condemned, not without reason; but those with wooden flooring and iron sides are good and practical. They would encourage one of our home industries, which has suffered greatly from the crisis, and a number of unemployed workmen would find work. We make ourselves, in this statement, the echo of several of our manufacturers who would be glad to see the Minister of Public Works entering on this new course."



OPENING OF THE NEW AVONMOUTH DOCK, NEAR BRISTOL, ENGLAND.

AVONMOUTH DOCK, BRISTOL.

A NEW dock, constructed for the port of Bristol, Eng., on the shore of the Bristol Channel, at the mouth of the river Avon, a few miles from that ancient and important commercial city, was lately opened by the Mayor and Corporation. This work has been eight or nine years in progress, being actually commenced in August, 1868. The total cost of dock, lock, warehouses, machinery, and plant is something like £600,000, or £200,000 more than the original capital of the company. The basin of the dock contains a clear area of sixteen acres, being 1,400 feet long and 500 feet wide, and has a depth of water at ordinary tides of 31 feet 3 inches, while a depth of 26 feet can always be maintained. The dock gates are the highest in the world, having a depth of no less than 49 feet and a width of 70 feet. The lock is 600 feet long and 70 feet wide, with a depth of water over 40 feet. The engineer was Mr. Brunlees, C. E., and the contractor Mr. Lawrence, of King's Lynn. The apparatus for opening and closing the gates, and for supplying the six large cranes which surround the dock with motive power, was provided by the firm of Sir W. Armstrong & Company, of Newcastle. The dock is in direct communication with the Great Western and Midland Railway systems, by means of the Port and Pier Railway, which runs from Avonmouth along the side of the river to the Suspension Bridge, whence the Clifton Joint Extension, under Durdham Down, runs into the Great Western at the Bristol terminus and the Midland at Fishponds. Within the past ten years the river Avon has had its bed deepened and its dangerous angles cut off, and new basins have been provided by the city authorities at the cost of nearly half a million sterling; and a dock quite as large as the Avonmouth dock will be opened next year at Portishead, about twelve miles below Bristol, to which the Corporation, having a large area of property near the docks, contributed £100,000. By next year, therefore, a million and a half will have been spent in the endeavor to attract a share of the large ocean-going steam trade to the West of England port, and in the hope of recovering the position Bristol once held of the second city in the kingdom.—*Illustrated London News.*

THE BUILDING OF A FRENCH LIGHTHOUSE.

IN the northwest corner of France, in the Department of Finistère, may be found the island of Sein, a few miles from the coast, and about halfway between Brest and Lorient. This island is prolonged seawards about eight miles by a long line of descending reef, the greater portion of which is always under water. Projecting thus into the sea, with no land between the end of the reef and the far-away shores of America, it may readily be imagined that the terrible swell of the stormy Atlantic is constantly beating against these lonely, half-drowned crags. A more unpromising site for a building could scarcely be imagined; and yet it was decided that the needs of commerce demanded a lighthouse on these far-reaching rocks, because they had attained an unhappy prominence as the scene of terrible losses of life and property, and because the prevalence of fogs made it impossible to give mariners sufficient warning from the distant island.

A commissioner examined the reef, and it was finally decided to select a rock known by the fishermen as Armen, although, when the selection was made, none of the engineers or sailors of the lighthouse service had succeeded in even effecting a landing. In the lowest tides the rock was about five feet out of water, and was about forty feet by twenty-five wide. The work appeared so difficult that the engineers who recommended it said, "It is a work excessively difficult, and almost impossible; but it seems that the supreme importance of lighting the reef forces us to try the impossible."

It was decided to begin operations by covering the rock with holes a foot deep, and about a yard apart. These holes were to be subsequently filled with bars of iron extending upwards into the masonry, thus connecting it with the rock, and consolidating the latter, of whose strength there was serious doubt. As it was only at rare intervals that it was possible to get on the rock, a contract was made with the fishermen of Sein, whose daily occupation would enable them to seize every favorable moment, to bore these holes whenever they could get an opportunity.

The fishermen commenced work in 1867. Whenever there was any chance of landing, the fishing boats hastened to the rock, and two men from each boat, with tools and life-belts, jumped on the rock, and while holding on with one hand, plied the hammer or the jumper with the other. They worked with feverish activity, and every few minutes were saturated with water from the waves that broke over their heads. If a man was washed away his life-belt supported him until he could be picked up by the boats. At the end of the year there had been but seven landings, only eight hours of work had been done, and but fifteen holes had been sunk on the highest part of the rock. It was the first step toward success. During the next year the difficulties were greater, as the work was to be done on the lower parts of the rock; but the price was increased, and experience enabled them to work to better advantage. The result of the year's work was sixteen landings, eighteen hours of work, and forty additional holes in the rock, besides some slight levelings.

The actual work of construction began in 1869. Bolts of wrought iron were inserted in the holes, and masonry with small stones and quick cement was begun. An experienced sailor lay on the rock with his back against one of the bolts and his face to the wind, and gave warning to the workmen of the state of the sea. When he announced the coming of a heavy wave they hastened to secure themselves; and they pushed their work to the utmost when he predicted a lull. All persons on the rock were provided with life-preservers and grass cloth shoes to prevent slipping. Whenever there was a chance of landing, a little steamboat started for the island, towing the small boats which alone could reach the rock. All stone was landed by hand, and also the cement, which was done up in small bags. At the close of the year twenty-five cubic yards of masonry had been laid, all of which was found intact when work was resumed the next year.

In 1870 there were eight landings, and twelve yards of masonry were laid. The work continued in this way until the close of the year 1875, at which date the total amount of masonry in the lighthouse was 455 cubic yards, and the structure was eight feet above the highest tides. The success of the work therefore appeared certain.

The finished tower will have a flashing light, of the second order, at a height of 92 feet above high tide. If the rock had been larger, a first order light would have been built. The tower will be solid up to 10 feet above high tide, and above that it will have eight stories or rooms for keepers, stores, and fog bell. The total cost of the work up to the close of 1875 was $70,000.

An excellent model and drawing of this lighthouse was on exhibition in the French Building at the Philadelphia Exposition; but in view of the vast number of interesting things to be seen there it may not be out of place to give our readers the above details of this difficult and interesting work.—*Cincinnati Gazette.*

NEW ARMSTONG GUN.

SIR W. G. ARMSTRONG & Co. have recently completed a breech-loading gun weighing a little over 39 tons, but called, for convenience, a 40-ton gun, which is by far the largest breech-loader hitherto constructed in England. This weapon has just been the subject of trials at the proof ground belonging to the Elswick firm, situated some forty miles north of Newcastle. The experiment attracted a large number of British and foreign artillerists. This new 40-ton breech loader is constructed upon the coil system, and is of 12-inch calibre. The breech mechanism follows generally the French pattern—that is to say, it consists of a removable breech screw, so cut away in the thread as to take its full hold by being turned through one sixth of a revolution. This screw draws back upon a hinged shelf, on which it swings back clear of the breech. But, though the gun is similar to the French breech-loaders so far as the screw is concerned, it is altogether different in the mode of stopping the gas. This is done by using a steel cup resting upon a slightly convex surface on the head of the breech screw. The edge of the cup is pressed by the screw against a step or shoulder in the gun, so that, when screwed up, the base of the cup is forced to take the form of the convex head on which it rests, and thus the lip is expanded against the circular surface which surrounds it. When the breech screw is opened, the cup recovers its form by its elasticity, and thereby releases its hold, and comes out on the screw with perfect freedom. The Elswick firm have made several smaller guns upon this principle, one of which fired upwards of 500 rounds in Italy with such excellent results that the Italian Government adopted the pattern, and ordered a very considerable number of these guns, many of which have been already supplied and are now in use. The experiments on the present occasion commenced with the trial of a breech loader of this description, weighing 26 cwt., and of 4½-inch calibre. This gun was fired with charges of from 7¾ lb. to 8½ lb. of pebble powder. The breech was opened after each round by the officers present with the utmost facility, and the stoppage of the gas was seen to be absolutely perfect. The mean velocity obtained with the lowest charge (viz. 7¾ lb.) was 1,491 feet per second; with the 8 lb. charge it was 1,548 feet, and with 8½ lb. 1,555 feet. With the highest charge the velocity instruments failed to act. But the chief attraction of the day was, of course, the firing of the 40-ton breech-loader. This was fired with a projectile weighing 700 lb., and with charges commencing at 160 lb. of pebble powder, and increasing by steps of 10 lb. to 180 lb. The velocities attained were very high, being 1,564 feet per second with 170 lb., and 1,615 feet with 180 lb. The last named velocity was the lowest indication given by the two instruments used, but taking the average of both instruments and including the observations with the same charge on a previous day, the velocity for a charge of 180 lb. with this gun is about 1,650 feet per second. The highest pressure in the bore was 19 tons per square inch. The stoppage of the gas was just as perfect in the large gun as in the smaller one, and the breech was easily and rapidly opened and closed by one man accustomed to the work and by the mere application of his hands, without using any tool whatever. The projectiles are of the simplest description, being neither leaded nor studded, but acquiring rotation by a copper band at the base which is forced into the grooves. At this trial the projectiles were fired into a deep bank of sand so as to be recovered after firing. On examination after recovery the copper band was found to have acted perfectly.

PHYSICAL SOCIETY.

Professor G. C. FOSTER, F.R.S., President in the chair.

Stratification of the Electric Discharge in Vacuum Tubes.—Mr. Spottiswoode exhibited some experiments and described his attempts to produce the effects as obtained by Mr. Gassiot and Mr. De la Rue, with batteries of several thousand cells by means of the induction coil. He showed the different forms of striæ produced in several different gases, and mentioned that the side towards the negative is always sharply defined, and that towards the positive gradually shades off into darkness. Mr. Spottiswoode has examined them by means of a rotating mirror, the mercury break being worked by the axis of the mirror so that the one only varies with the other. It was thus clearly ascertainable whether a band was progressing towards either pole or remaining stationary, or was intermittent, according as the line observed in the mirror was inclined or horizontal or broken. He considers that the ordinary break prolongs the sparks, so as, in some cases, to give rise to the ill-defined nature of the striæ, and he showed two forms of contact breaker adapted to these experiments. In the first the breaking was effected by a steel rod caused to vibrate by an electro-magnet, the number of these vibrations being determined by the musical note produced. In the apparatus now usually employed, however, a brass wheel is caused to rotate with great rapidity, the tops of the teeth are covered with platinum, the spaces between them being filled in with ebony. It was shown that if the current be made and broken by a wire resting on the rim of this wheel, the bands may be caused to move in one direction or the other, or remain stationary, according to the velocity of rotation of the wheel. A very ingenious arrangement, invented by Mr. Spottiswoode's assistant, Mr. Ward, was employed for introducing resistance into the secondary circuit, and thereby adjusting the strength of the current to suit the velocity of rotation of the wheel. It consisted of a spiral column of mercury surmounted by a vessel containing a badly conducting liquid, and by raising or lowering a cup connected with the base by means of an india-rubber tube, the amount of mercury present in the column is increased or decreased, the resistance offered by the column of constant length of course varying in the inverse proportion.

The Photographic Image.—Capt. Abney, R.E., read a paper, prefacing it by a brief account of two theories, the chemical and the physical, which are held regarding it. On the former a molecule of bromide of silver is split up into sub-bromide and bromide, the latter which is absorbed; and, on the latter theory, light acts mechanically on the molecule shifting the positions of the atoms. Poitevin has done much to confirm the former of these by placing a film of silver iodide in contact with a silver plate, when he succeeded in obtaining an image both on the film of iodide and on the silver plate, produced by the liberated iodine. Capt. Abney has performed the following experiment: A portion of a dry plate, which had been exposed, was wet with a sensitive collodion emulsion of bromide of silver and developed by the alkaline method; the films were separated from the glass and from each other by means of gelatinized paper, and were found to bear images; and the same result was obtained when the emulsion was added after exposure, development, and fixing. These experiments entirely disprove the supposition that only those molecules acted on by light are reduced. If the two films be separated by a thick layer of albumen, the lower picture develops as a negative and the upper as a positive. Capt. Abney is now engaged in an attempt to determine the attraction exercised by the sub-bromide, and this, it is hoped, will do much towards the complete solution of the problem of the photographic image.

Mance's Method for Determining the Intensity of an Electric Current.—Mr. O. J. Lodge proposed a modification, of which Wheatstone's bridge is an application; it depends upon the fact that if three conductors be united at a point A, and their extremities B C and D be united by three wires B C, C D, D B, the resistance of B C will be independent of that of A D, if A B is to A C as B D is to C D. In the arrangement proposed by Mr. Lodge, four wires are joined in the form of a square, and the circuit can be completed across one diagonal by means of a key, and in the other diagonal is included a condenser and a galvanometer with a long fine wire. The greatest sensitiveness is obtained when the resistances in the four sides are equal. A great advantage of this method consists in the fact that it is equally applicable to the measurement of small and great resistances. Mr. Lodge then showed a modified form of Daniell's cell, capable of giving a constant current for a considerable period. A glass cell, half filled with dilute sulphuric acid, contains two vertical glass tubes, one of which, open at both ends, is traversed by a zinc rod, while the other is closed at its lower end and contains cupric sulphate, from which rises a copper wire. The portion of the copper tube projecting above the acid is sufficiently moist to enable the current to traverse its surface, while the zinc sulphate is prevented from re-acting on the copper.

Separating Cocoon-Thread.—Professor Guthrie incidentally mentioned that the difficulty experienced in separating the fibres of a cocoon-thread may be obviated by boiling the thread in carbonate of potash, when the natural resin is sapcnified and the fibres may be easily split.

Convection Currents.—Mr. Wilson showed an arrangement for exhibiting convection currents in heated water. It consists of a small glass cell with parallel sides. In the base of the wood dividing the sides is cut a slight depression, to expose a brass tube which traverses it horizontally, and is open at one end, while the other is bent at right angles, and connected with a flask containing water. The brass tube where it is exposed in the cell is surrounded with a jelly formed of gelatine, containing rose aniline, and the cell is filled with water and projected on the screen. When the tube is heated by boiling the water in the flask, the jelly is liquified, and the liberated coloring matter rises in the water, showing the direction of the heated current.

MOSS COPPER.

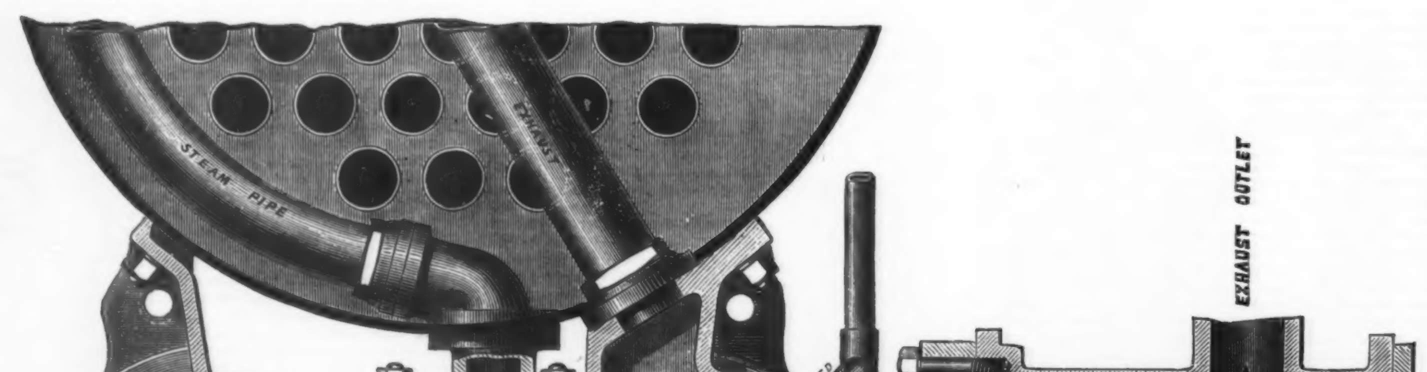
By W. M. HUTCHINGS.

DOUBTLESS many readers of the *Chemical News* have, like myself, taken great interest in Professor Liversidge's experiments and observations on the formation of moss gold and silver (*Chemical News*, vol. xxxvi., p. 68, and would welcome any further investigations and explanations bearing upon this very interesting and little-understood subject. What is, perhaps, the most interesting and curious fact recorded by Professor Liversidge is the very low temperature at which the "moss" is formed. In the case of moss copper, I was greatly struck by some observations which I made during some experiments a couple of years since, and which I have repeated several times since reading the paper by Professor Liversidge. I took about ½ lb. of regulus (containing 65·9 per cent. copper) and fused it under borax in a clay crucible, pouring the molten mass into an iron mould. After cooling slowly (by using a thin mould and standing on a hot plate) the regulus was found to contain a large amount of disseminated copper, the fractured surface showing numerous veins, and little nests of needles and jagged points, in small cavities in the regulus, even to the naked eye, while a lens or microscope showed the entire surface dotted with particles of copper. When a small portion of the regulus was fused as above, and cooled very rapidly, very little copper was visible under the microscope.

When a large button of regulus (½ lb. as above) had cooled in the mould for some time, so that it had been quite solidified for some minutes, it was laid on an anvil and broken in two by a blow with a hammer. It was still much too hot to hold in the hand, but had cooled far below redness, even in the centre. At the moment of fracture, the surfaces exposed were perfectly clean and lustrous; looked at quickly with a lens, they showed only the little veins and nests and imbedded particles of the disseminated copper; but in the course of a minute or two they were seen to become slowly covered with a growth of minute copper filaments, which increased till in some places it resembled a coarse velvet. After three or four minutes one of the halves was again broken in two, and again the fresh and lustrous surface of regulus exposed, which contrasted strongly with the surface already covered with "moss." The piece was now just cool enough to be held in the hand. In the course of a few minutes this also showed moss copper on the surface, though not nearly so much as the first fracture, and only in patches, which formed very slowly. In all cases the growth is most extensive on the hotter parts of the surface—those nearest the centre—and if large buttons of regulus are broken while still much hotter than above mentioned, a far thicker covering is rapidly obtained.

Of course there is no question here of this "moss copper" being formed at a temperature sufficient to soften copper. Even at the time of the first fracture, the centre of the button was not nearly at the temperature of melting lead, and when fractured the second time the pieces were certainly not over 100° C. Nor is there any oxidation of the surface of the regulus, for, where this is seen in amongst the copper filaments, it retains its lustre as when freshly broken.

Seen under the microscope, these filaments (which in these small experiments are exceedingly minute), exactly resemble the larger ones described by Dr. Percy, being deeply grooved and striated. Many of them are broad and flat, like blades of grass, as described by Professor Liversidge in the case of moss silver, and many seem to show plainly that they were formed by the union of several finer threads, as they look, when magnified, exactly like coiled wire rope.—*Chemical News.*



EIGHT-HORSE POWER TRACTION ENGINE.—MARSHALL & CO., BRITANNIA WORKS, GAINSBOROUGH, ENGINEERS.

MARSHALL'S TRACTION ENGINE.

WE illustrate a traction engine, designed and constructed by Messrs. Marshall, Gainsborough, Eng., and exhibited by them at the last Smithfield Club Show. Our drawings nearly explain themselves. It will be noticed that the engine is built with side frames somewhat like a locomotive, and these frames carry the gearing, and so spare the boiler from the strains to which it would be otherwise subjected.

The engine has only a single cylinder; the place of the second cylinder in an ordinary locomotive being occupied by a water-heater shown to an enlarged scale in the lower part of the page. It will be seen that the exhaust flows through a copper pipe coiled up in a cast-iron cylinder, through which the feed-water is passed. By taking off the lid, the whole interior becomes accessible for cleaning and repairs. The throttle-valve arranged, in the valve-chest as shown, is worked by a small high-speed governor, placed between the frames at the leading side of the engine.—*Engineer.*

A NEW METHOD OF DETERMINING MELTING-POINTS OF METALS AND OTHER SUBSTANCES.

By Dr. HIMLY.

A KNOWLEDGE of the boiling points of liquids under the same atmospheric pressure has the same high value as a means of distinguishing them from each other as crystalline form has in the case of solid bodies. These constitute distinguishing physical characteristics in both cases; indeed, in cases of liquids, their purity is determined by the constancy of the boiling-point, of course excepting those liquids which are decomposed in the act of evaporation. As regards the temperature of the boiling-point, certain physical conditions have been discovered as dependent on this, especially in the case of substances belonging to organic chemistry. How is it, however, as regards the temperature of the melting-point? Here we must admit that the connection between the temperature of the melting-point and the physical constitution of the body is still wholly unknown to us. The importance of a knowledge of the melting-points is evident, if we only take into consideration the number of organic bodies whose melting-points are constant (when pure). How little we know of the connection between the molecular constitution of the body and its melting-point, may be illustrated by merely referring to the elementary substances. Why, for example, do platinum and iridium only melt at the highest temperature of the oxyhydrogen flame, while mercury is already liquid at 39° C. below the freezing point?

The melting-points of other metals lie between these extremes, but the varying densities of the metals give us no insight into this. To follow this inquiry further would lead too far from our present purpose. I will only put one more question: What physical condition determines the fact that the metal calcium melts already at a red heat, while when united to oxygen (a gas so volatile as to be incapable of liquefaction), it is as infusible as carbon?

The number of melting-points reliably determined, whether in the case of simple or compound bodies, is (in proportion to the vast number of bodies) extremely small, and yet it will be only possible to deduce laws regarding the physical conditions which determine the melting-points, after a large number of these melting-points have been accurately observed. Under these circumstances, I think, therefore, I am doing a service to science if I make known a method for determining the melting-points which is easily applied and affects a remarkable accuracy, and is applicable equally to good and bad conductors of heat, such as metals, fats, etc.

In *Dingler's Polyt. Journal* (vol. 201, p. 250), a very interesting method of determining the melting-points of organic substances which are non-conductors of electricity is described by J. Löwe. This method consists in coating a platinum wire with a layer of the substance whose melting-point is to be determined. The platinum wire dips into a bath of mercury, which latter is connected with an electric bell, a galvanic cell being placed in the circuit. So long as the coating of substance on the platinum wire remains unmelted, the bell remains silent. The bath of mercury is gradually heated, the coating of substance melts, and the wire makes contact with mercury, and thus closes the electric circuit. The bell rings, and at that instant the temperature is read off by a thermometer placed in the bath of mercury. The difficulty of determining with accuracy the melting-points of substances which are bad conductors of heat, such as fats, etc. (especially when they possess a considerable latent heat), is well known, as also the imperfection of the method hitherto employed for this purpose, which consisted in placing the substances to be examined in capillary tubes, and in observing an approximated thermometer as soon as the melting began. On account of this difficulty, the ingenious method devised by M. Löwe was all the more to be welcomed. It is to be regretted, however, that the experiments made by a former scholar of mine, C. H. Wolff (and described in the *Archiv. d. Pharmacie*, vol. 3, 1875) have shown that the degree of accuracy expected was not attained, as, for example, in the case of a piece of white wax, M. Wolff obtained, in a series of twenty-four experiments, results varying between 61·2° C. and 65·4° C., or a difference of 4·2° C. This circumstance caused him to diminish the thickness of the platinum wire, and to alter its form, by which means he says that, after many experiments, he reduced the difference to only 0·5° C. That with this method absolute accuracy was unattainable is no doubt to be ascribed to the difference in the conducting power for heat possessed by the platinum of the wire and the mercury of the thermometer.

Induced by the fact that the Royal Dockyard of Wilhelmshaven, besides requiring exact quantative analysis of different white metals (of which, remarkably enough, two specimens contained about 5 per cent. of mercury) also required exact determinations of the melting-points of the same, I have for this purpose employed a method which has only that in common with M. Löwe, in possessing the arrangement of an electric bell. The object to be attained was not only to avoid the errors above alluded to in the determination of the melting-points of bad conductors of electricity and heat, but also to render the method applicable to the determination of the melting-points of substances which are good conductors of electricity and heat. This new method is as follows:

The glass mercurial thermometers employed are made with thin ogival-shaped bulbs, and the bulbs (and also part of the tube) are chemically coated with silver. As the silver coating is very easily damaged, it is well to strengthen it with a coating of copper in the ordinary way by means of a weak galvanic current and a solution of sulphate of copper. Before this, however, a fine annealed copper wire is to be wound round the thermometer tube a little above the bulb. The wire is then to be laid along the side of the thermometer tube and fastened to it by an india-rubber band, to avoid all jerks on the wire, as the latter is afterwards to be connected with a galvanic cell. The coating of copper is allowed to extend over the point where the wire is attached, by which means a better metallic contact is insured. For the determination of the melting-points of metals, or alloys and good conductors of electricity, the copper coating may be somewhat thicker for the sake of durability, while in the case of investigations with non-conductors, the copper coating should be thin, or may be dispensed with altogether. It remains now to describe the special method of procedure.

Determination of the Melting-Points of Metals and Good Conductors.—For this purpose a U-shaped tube with arms about 10 centimeters long is required, the glass of which, for the sake of durability, should not be too thin. The arms should be parallel and close to each other. The bore of the tube should not be much larger than the bulb of the thermometer employed.

The metal or alloy to be experimented upon is to be cast in the form of small bars, about the same thickness as the bulb of the thermometer. Besides this, an iron bowl or crucible is wanted, which can be slowly heated by means of a spirit-lamp or gas-burner. According to the height of the melting-point to be determined, the crucible is to be filled with mercury or some fusible alloy. To carry out the experiment, the thermometer with its attached wire is to be placed in one arm of the U-tube, and the small bar of metal to be tested in the other. The bar should be pushed in quite up to the bend, so that the bar and the bulb of the thermometer are as near together as possible without touching. A conducting wire reaching down to the bend of the tube is placed by the side of the metal bar, the wire being of such a length as to admit of being conveniently connected with a galvanic element. The whole arrangement with the U-tube is attached to a convenient support with clamp, so that the U-tube can be immersed in the bath of mercury or melted alloy.

An electric bell (with galvanic element) is inserted in the circuit between the two wires attached to the thermometer bulb and metal bar respectively. The complete circuit is therefore only broken at the bend of the U-tube, and as long as this interruption lasts, the bell is silent. When, however, the heating of the metallic bath in which the U-tube is immersed has gone so far that the metal bar in the tube melts, then the melted metal closes the electric circuit. At the same instant the bell rings, and the reading of the thermometer is taken. When it is considered that the thermometer and the metal bar are exposed under perfectly similar conditions to the source of heat, the accuracy of the melting-point thus determined must be self-evident. This method of experimenting is of course only to substances which are conductors of electricity, and whose melting-points are such as to permit the use of a mercurial thermometer. This principle would also be applicable to metals with high melting-points, provided the U-tube were made of some refractory material, and a suitable pyrometer substituted for the thermometer.

Determination of the Melting-Points of Substances, Nonconductors of Electricity and Heat.—For this investigation also the metallically-coated thermometer, with conducting wire attached, is employed. The substances to be examined are first melted, and just when solidification begins again to set in at the sides of the containing vessel, the metallically-coated bulb of the thermometer is dipped for an instant into the substance. In this way the bulb of the thermometer is coated with the substance to be examined. It suffices if the coating be from one to two millimeters thick. Further, an iron crucible is required with a hole formed in the lid. In this hole a thin porcelain crucible filled with mercury is placed, which dips well into the liquid in the iron crucible. The liquid in the iron crucible may consist of glycerin, or a solution of chloride of calcium in glycerin, which may be heated to a temperature of 200° C. without giving any trouble. If higher temperatures are required, then it would be well to use a bath of liquid alloy or mercury.

The carrying out of the experiment is very simple. After the bulb of the thermometer (and a small part of its tube) has been coated in the manner described with the substance to be examined, and the whole has become cool again, then the thermometer is immersed in the mercury of the porcelain crucible. The wire attached to the silvered coating of the thermometer and a wire dipping in the mercury are then respectively to be connected to the circuit containing the galvanic element and bell. Then the glycerin bath is to be slowly heated.

Since now the substance whose melting-point is to be determined is in actual contact with the bulb of the thermometer itself, it is clear that at the instant of melting (when the bell rings), the thermometer must give the temperature with wonderful accuracy. This is in itself so evident that it is not necessary to refer for illustration to the number of experiments which have been made.

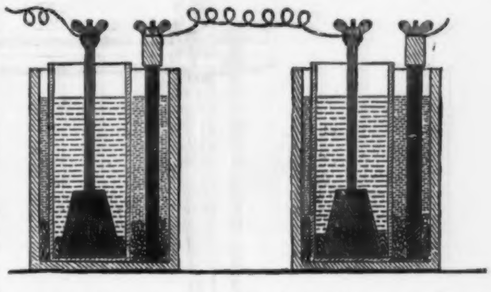
It may just be added, in conclusion, that in measuring the melting-points of metals or alloys, the level of the metal bar to be tested should be completely below the level of the melted substance in the heating bath, and the bath should be heated uniformly, *i.e.*, not only underneath, but at the sides. The uniform heating of the bath may be best attained by stirring its contents with a small iron bar; also it is well to take care that the U-tube is not irregularly bent, so that there is no unevenness in the bend of the tube to obstruct the free downward flow of the metal from the metal bar.—*Pogg. Anal.*

MERCURY-BICHROMATE BATTERY.

MENTION has been made of the new form of bichromate battery recently introduced by Mr. John Fuller. The introduction, however, of a new battery by one whose experience on the subject extends over so wide a range as Mr. Fuller's, deserves something more than a passing word. So many galvanic combinations of one sort or another are almost daily being brought forward that we are compelled to pass by the greater number of them unnoticed. It is therefore no small comfort when amongst the crowd we alight upon one whose behavior thus far does not belie the fair promise which it at first sight held out, and whose employment in the every-day work of practical telegraphy seems likely to be attended with success.

The old bichromate of potash, carbon, or electropoion battery, as it has been indifferently named, was thought by most people to have become all but a matter of history, and few anticipated its re-appearance on the scene of action in active competition with such rivals as the Daniell and the Leclanché. Mr. Sivewright, speaking of it in his paper, "On Batteries and their Employment in Telegraphy," read before the Society of Telegraph Engineers in the beginning of 1875, says: "The amalgamation of the zincs, a point of vital importance in both this and Grove's battery, had constantly to be seen to;" and further on he adds: "Both (the bichromate and Grove's) have now had their day, so far as general practical working for telegraphic purposes goes, and will in all probability be speedily numbered amongst the experiences of the past. The wonder really is how, in the face of the other forms of batteries, they could ever have stood their ground so long and so well as they have done." In the discussion which followed consequent upon the reading of this paper, Mr. Higgins, of the Exchange Telegraph Company, stated that "the battery, although the best for their use, was a most convenient one."

Now, Mr. Fuller, by taking up "the point of vital importance," and rendering his zincs, so long as they last, permanently amalgamated, has not only rescued the bichromate battery from being included amongst the lumber of the past, but has given to it a fresh lease of life, and the prospect of a longer existence than even in its palmiest days it could formerly have dared to hope for. In the accompanying figure two cells are shown. The carbon plate is placed in the outer vessel in a solution of the bichromate of potash. Three ounces of the crystals of this salt are placed in each cell, in a solution consisting of nine parts of water to one of sulphuric acid. The zinc element, which is of the shape shown in the figure, is placed in a porous tube, to which an ounce of mercury is added, and which is then filled up with water only. The addition of this mercury is the essential feature of the battery, and to it the disappearance of the main objections which were previously to be urged against the old bichromate form is chiefly due. The zinc plate is in this way kept permanently amalgamated so long as it lasts; the consequence is that not only is the internal resistance of the battery largely diminished, but its constancy—the *sine qua non* of any galvanic combination for telegraph purposes—is to a



great extent insured. The action, after the battery is charged and the elements are connected with each other, commences almost immediately, and reaches a maximum in the course of a few hours.

The maintenance is a very simple matter. On an ordinary working circuit, such, for instance, as a single needle or moderately busy printer, no extra crystals will be required, after the battery is once set up, for a period of six months. So long as the solution remains of an orange color, none, it is stated, will be required; only when it begins to assume a blue tint need crystals be added to it. The only specific fault which developed itself in the battery during an experience of over eighteen months was the eating through of the rod of zinc element, under the influence of the acid employed. This danger has been effectually got rid of by covering the rod with some protective covering—wax, india rubber, or the like. An objection urged against the battery was that even when the cell was not in action, the zinc seemed to be acted upon and gradually to disappear. Such may doubtless be the case, for the mercury has the power of effecting this; but from the resulting amalgam which is thus formed it will be found that an electro-motive force will be produced as powerful as that in the original combination; and the strength of current will be in no way diminished so long as a good connection is insured between this amalgam and that portion of the metallic zinc which remains.

The electro-motive force of the combination is equal to about two volts, or twice that of the Daniell's cell; the internal resistance, by varying the thickness of the porous vessel and the strength of the solution, may be made to vary from half an ohm up to four ohms, according to the work which the battery is called upon to perform.

In point of cost, this battery compares very favorably with those which are at present employed in England. Taking, for instance, the Daniell, and assuming that both are employed on hard-worked wire, say joined up in closed circuit or on one of the railway block-signal circuits, the statistics of the cost of each will be found to be as follows:

Daniell.

Prime cost of a ten-cell trough fitted complete	£1	2	4
Sulphate of copper for six months	1	1	8
Complete renewal at the end of six months	0	14	10

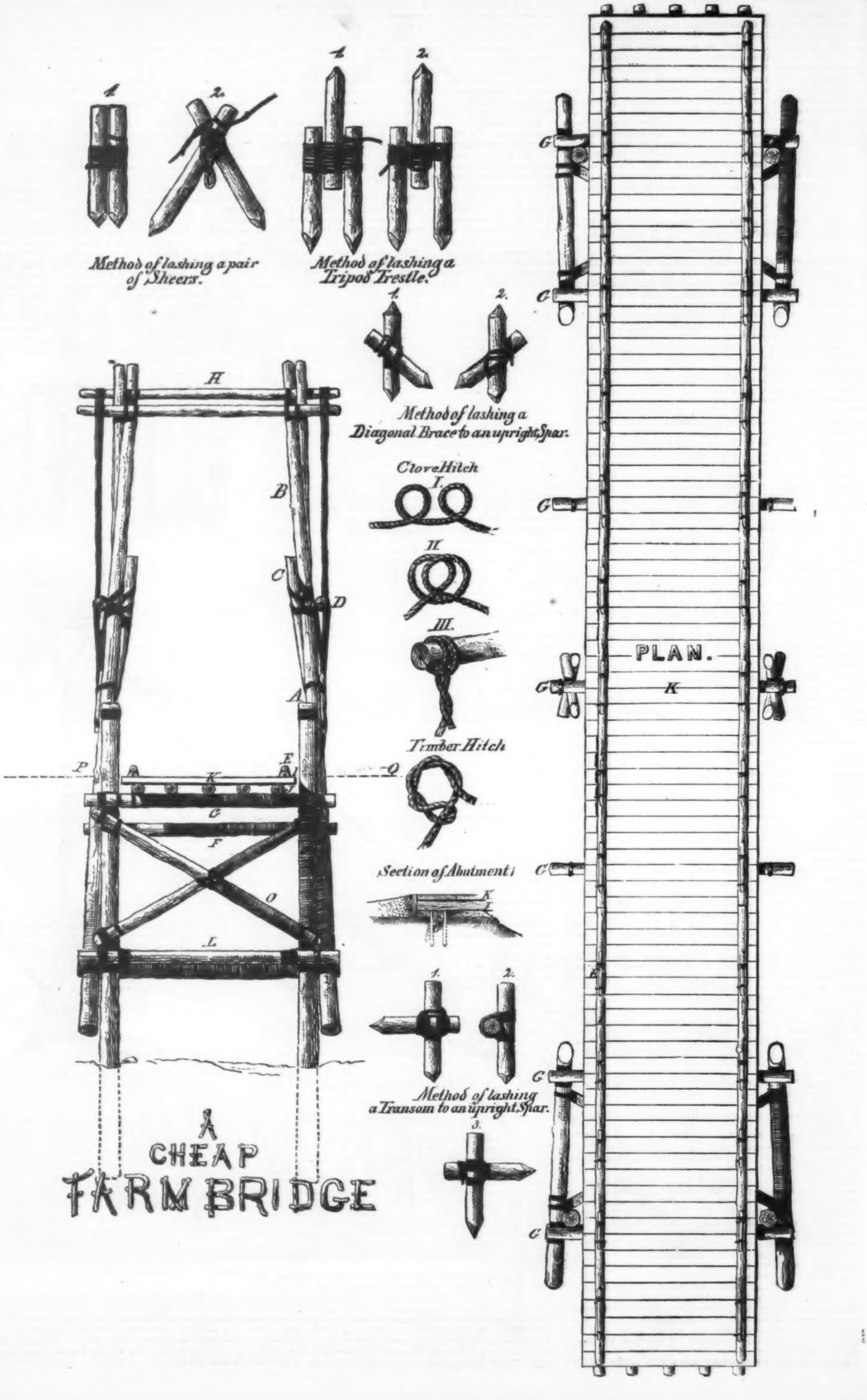
Fuller's Mercury-Bichromate.

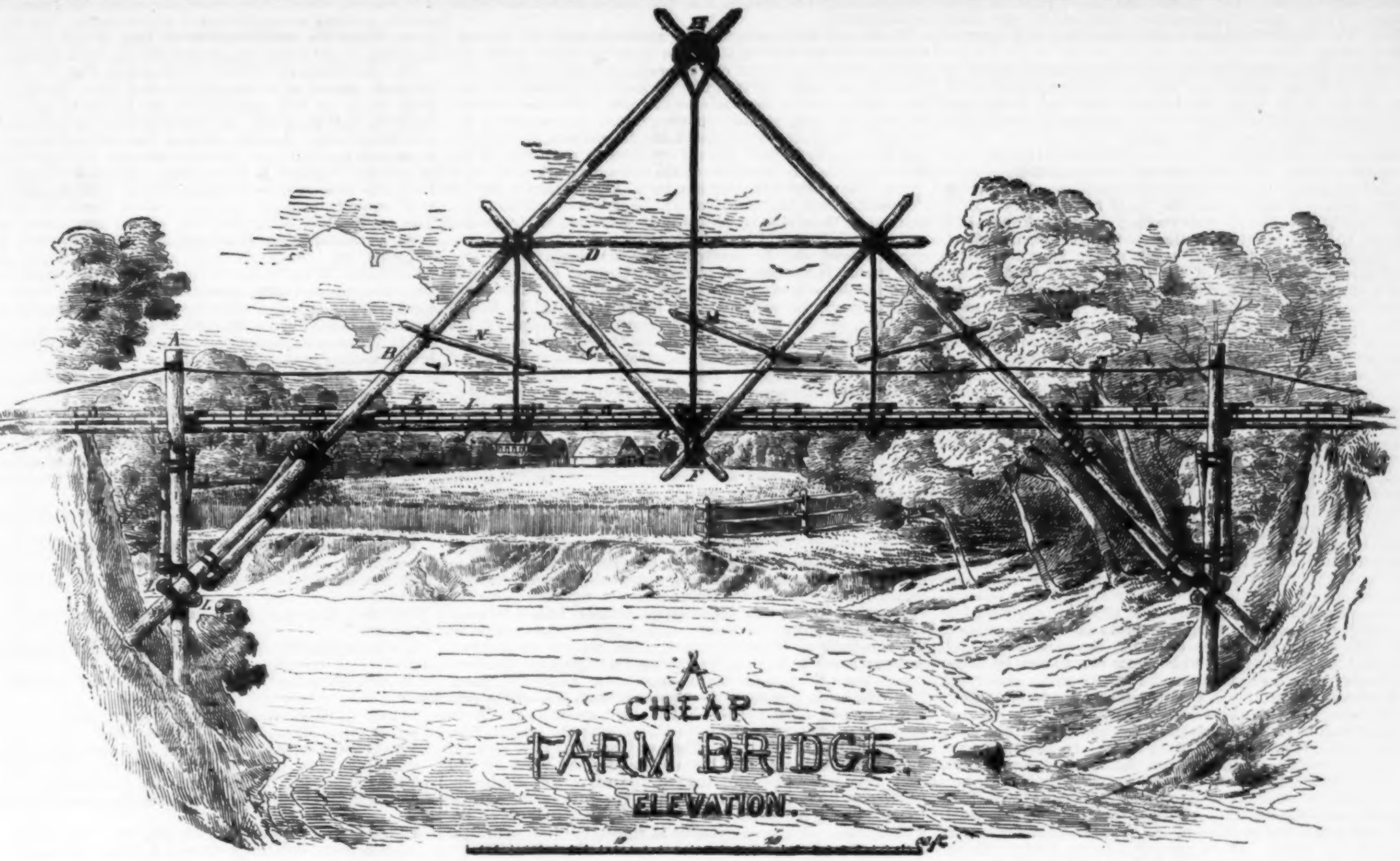
Prime cost of a three-cell battery (equivalent to a ten-cell Daniell)	£0	15	0
Bichromate of potash and sulphuric acid for six months	0	3	7
New zincs and mercury at the end of six months	0	2	8

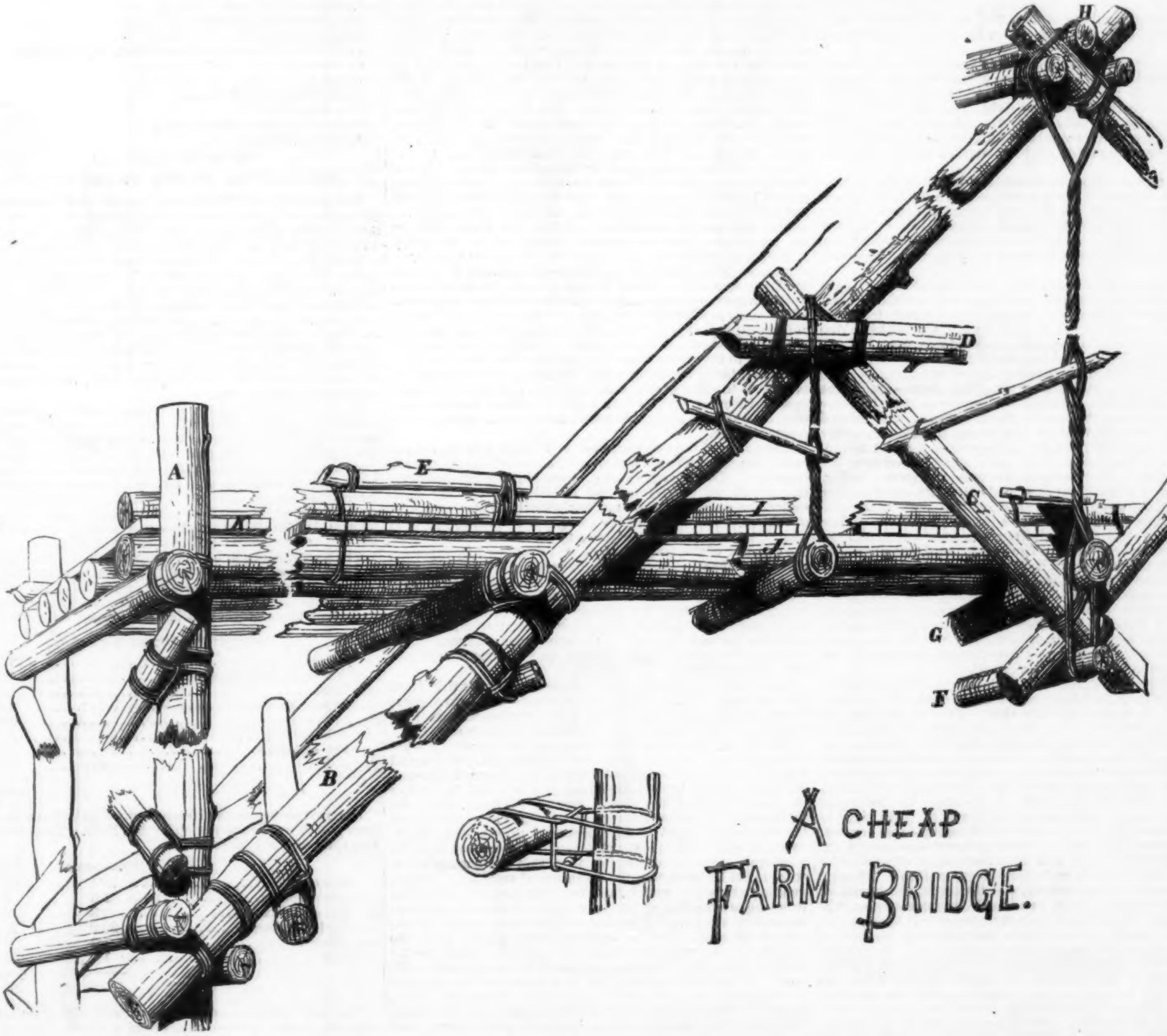
Neither the carbon plates nor porous pots are taken into account. No evidence has yet come before us as to how long these are likely to last. The former would appear to be practically indestructible, and no appearance has hitherto been observed of any local action going on with them, nor of the peeling and cracking of the porous partitions which at times prove so troublesome in the Leclanché.

Generally speaking, this mercury-bichromate battery will be found far more economical, and, with few exceptions, as reliable as the Daniell. It is well adapted also for medical and experimental purposes, such as the working of induction coils, firing of fuses, heating platinum wire, and the like, combining, as it does, at a much smaller cost, the good qualities of the Grove with the convenience in handling of the Daniell.—*Telegraphic Journal.*

THE WESTERN UNION TELEGRAPH COMPANY have planned to mark the exact hour of noon in New York, by dropping a large time-ball from its staff high over their building, and in a position to be seen from the shipping in the harbor. The exact moment of noon will be indicated in New York by telegraph from the United States Naval Observatory at Washington.


Method of lashing a pair of Sheers.
Method of lashing a Tripod Trestle.
Method of lashing a Diagonal Brace to an upright Spar.
Clove Hitch
Timber Hitch
Section of Abutment
Method of lashing a Transom to an upright Spar.
PLAN.
A CHEAP FARM BRIDGE





A CHEAP FARM BRIDGE.

IN the Government Building at the Centennial Department of Military Engineering was exhibited by the School of Instruction at Willett's Point, N.Y., a model of a spar bridge, to be used in campaigns for crossing unfordable streams. Of this bridge a view and short description were given in the SUPPLEMENT, No. 31, page 480. The design of the model at the Centennial was taken from an English work on Military Engineering, published for the use of the Chatham School of Instruction, in 1870.

This bridge, from its simplicity, effectiveness, and economy of cost, is adapted especially to farm and other roads, for the crossing of small rivers, streams, and gullies, where the travel does not demand or warrant an outlay sufficient for the erection of more costly structures. As a temporary structure, in case of a bridge being carried away by a swollen river, or being destroyed in any other way, it will also be

found very useful. For parks and large gardens, these bridges would make picturesque additions to the landscape. For the size of timbers used, there is a high percentage of safety.

The strength of such a bridge was amply demonstrated by the fact that the model exhibited at the Centennial—8 ft. long, 3 ft. 10 in. high, 16 in. broad from out to out, and whose largest spars were only 1½ in. in diameter—easily supported the weight of an average man.

We propose herewith to give a detailed description, so as to enable farmers, and others who wish to avail themselves of the information, to construct for themselves, at slight expense, similar bridges when they may be necessary. Any one who is capable of constructing a hayrick has skill enough to build a bridge similar to the one here described. No nails, bolts, or cleats are used, as the swaying of the parts incidental to the use of the bridge would render them worse than useless, even very detrimental. The timbers are lashed together by hempen rope, or, when intended as a more permanent structure, by chains or wire rope. Ten or twelve men, if haste was necessary, could, in a day, or in less time, construct such a bridge, the materials being at hand.

The materials and implements necessary for the building of the bridge consist of a quantity of rough timbers of some strong, durable wood—it is better to leave the bark on; some thick boards for the roadway; a quantity of rope or chain, and either of what are known as "marlin" or "spun yarn," to be used as a "seizing" material.

A front and side elevation and plan of the bridge are given, showing in full detail the different parts. To illustrate the tying of the knot fastenings, upon which depend to a great extent the bridge's stability, several diagrams are given, which show in detail how each separate knot is tied.

A scale is given on the front elevation; but roughly assuming the length of any proposed bridge to be 100 units, the proportionate dimensions of the other parts will be as follows: The standard of the pier frame (A) in the drawings would be 32 units long; the supporting standards of the frame (B) 56 units; the tension timbers (C) 31 units; the cross timbers (D) 35 units; the width of the bridge from out to out, 16 units; width between standards of pier frames, 12 units; and width of roadway, 11½ units. The chief timbers would be 1¼ units in diameter, and the others in proportion.

There should be in all about 15 short pieces like (E) setting on the split spars (I) to bind the planks. In the binding of the spars together, all unnecessary lashing has been avoided. As an instance, it is not necessary to lash together the two (B) timbers at the top, or to secure the cross-pieces (F G) and the upper spar at H. All ropes should be well secured, and safe knots tied as shown, and sufficient lashings made to resist the strain. If, in case of a heavy bridge, chains are used, the safest fastening would be made by passing one link through another, and then putting as a "toggle" a piece of stout wire or small bar of iron through the inserted link. If the ends are bent, the "toggle" will not slip or work out of place.

The ropes or chains in the center of the bridge, and of each half, are double; and to obtain the proper tension, "toggle poles," as at M in the principal drawing, are used to twist the ropes or chains sufficiently tight; when this is the case, the toggle poles are fastened to the adjacent timbers—the whole disposition being similar to that used for a bucksaw, or when a load of saw logs are to be bound down by a tightening pole.

We will now describe the building of such a bridge, assuming that the timbers of the required length and all the materials and implements are on the ground. As timber sheers and tripod trestles will be necessarily used during the erection of the bridge, we will commence by describing the methods of lashing spars together to form these accessory structures.

In forming a pair of sheers, the two spars of equal length are laid parallel to each other, with their butts on the ground, the ends below the proposed lashing being raised from the ground and supported by a short spar. A clove hitch (see drawings on Plate 2) is then made around one spar, and the lashing is taken loosely eight or nine times around both spars above the hitch, without allowing any of the turns to cross each other. Then a couple of frapping turns—*i.e.*, turns which longitudinally cross the others, and draw them together—are taken between the spars, round the lashing, and finished up with a clove hitch above the round turns on the other spar. The spars will appear as shown in the first figure. The butts are then opened out, and a sling passed over the fork, to which the block is hooked or lashed, as shown in Fig. 2. The fore and back guys are made fast with clove hitches to the tip of the spars, and so arranged that their heads will be drawn together when the strain comes upon them. Then foot ropes are secured to the butts of the spars and to pickets, and the shears are raised. The tackle need not be hooked on at first if it is heavy, but it can afterwards be drawn up by a whip secured near the top of one of the spars. When the rope of the whip to be used for this purpose is secured to the block, it should be bent on to the eye in the strop of the block, and not to the hook. The block can then be raised to the required height, and it can then be hooked into the two parts of the sling, which would be a very difficult operation if the whip were made fast to the hook itself.

In lashing together the spars which form a tripod trestle, the distance from each butt, at which the centre of the lashing is to be, is marked on each spar. Two of the spars are then placed parallel to each other, at a distance from each other somewhat further apart than their own diameter, the tips resting on a small spar, as before; the third spar is then laid between them, its butt being placed in an opposite direction. The spars are so placed that the marks are in line. As before, a clove hitch is made on one spar; the lashing is then taken loosely over and under the three spars eight or nine times (see Fig. 1). A couple of frapping turns are then taken between each pair of spars in succession, round the lashing, and finished off by a clove hitch taken around one of the spars. It will then appear as shown in Fig. 2. A sling is then passed over the lashing, and the tripod can be raised. After these lashings have been made, the constructor will have acquired some little experience, but it will be found advisable to practice several times the following method of lashing a transom of ledger to an upright spar. In the case described see Plate 2), the transom is placed in front of the upright, a clove hitch is made around the upright below the transom, the lashing is then brought under the transom, around in front of it, horizontally behind the upright, down in front of the transom, and back again behind the upright below the clove hitch, and so on, following round, keeping on the outside of and not overriding the turns already made. After having given from six to seven turns, a couple of frapping turns are taken between the spars round the lashing, binding the whole firmly together. The lashing is then finished off with a clove hitch taken around one of the spars, or any part of the lashing through which the ropes will pass

To tighten up the lashing, it is well beaten with a handspike or axe-handle.

Having all the spars and other materials ready for the construction of the bridge, a section must be taken across the stream, where the center of the proposed bridge will be. If, as usual, the banks be irregular, it may be necessary to take two sections where the butts are to come. Set these sections off, full size, with pickets, on the ground, on one side of the stream. The points of support being determined, are marked, and the span is divided into six equal parts, exclusive of the shore rays, and the positions of the transoms marked by short spars. The spars for the pier standards (A) must then be laid on the section, and the positions of the ledgers and transoms marked on them; the centers of the ledgers and the transoms, and the points at which they are to be lashed into the standards, should also be marked. The standards for the two pier frames must then be placed in position on each bank opposite the site of the proposed bridge, their butts being placed toward the stream. The ledgers (L) must be lashed on above, and the transoms (G) beneath, the standards at the marked places; then the diagonals are lashed to the standards (two butts and one tip being above, and one tip below), and to each other. In lashing the frames, the butts of the spars should be further apart than the tips, insuring greater stability. The splay should be about, say, one in twenty. Two men will be required to work at each lashing, and great care must be taken that the spars be kept all the time in their relative positions. The post-holes for the pier standards must then be prepared, and the frames are then to be lifted into their proper positions on each bank. The supporter standard frames are then laid out, with the butts toward the stream, and placed according to the measurements, so that one frame will fall inside the other when they are placed across the stream. Everything is prepared in a similar manner to the pier standard frames, except that the ledgers are lashed on below, and all the main and upper transoms above, the standards. Temporary diagonals are securely lashed between the main and upper transom, and single blocks secured to the standards of the wide frame. The pickets for the foot and guy ropes to be used in raising the supporter standard frames must then be driven in—the former about two paces from the bank, and about four paces to each side of the central line; and those for the latter, about twenty paces from the bank, and about ten paces to each side of the central line. (See diagram on Plate 2.) The foot ropes are then secured by timber hitches to the butts of the frames, the fore and back guys to the tips, and the guys passed across to the opposite side by means of spun yarn. The guys of the narrow frame should be inside the guys and the standards of the wide frame. When everything is ready, the frames are got into position, both at the same time, if there be sufficient men. One man must be placed at each foot rope, and one at each back-guy, to slack off, as required—each rope having two turns taken around their respective pickets. The others then raise the frame and launch it forward, those who man the fore-guys on the opposite bank assisting, until the frame is balanced on the edge of the bank. The butts must then be lowered into nearly their final position by slacking off the foot ropes, and the head of the frame is then hauled over until beyond the perpendicular, and then lowered into nearly its final position by slacking off the back-guys, assistance in guiding it being rendered by the men at the fore-guys. The guys are then made fast to the pickets until all is ready on both sides of the stream. When this is the case, the two frames are gradually lowered, being guided by the fore-guys until they are locked, and the standards of the narrowest one rest on the upper transom of the widest, between its standards, and the wide frame rests on the transoms of the narrow one, outside of its standards. A couple of roadbearers are now got out on the main transoms, and men climb up the standards to assist in placing the cross spars (D). These should then be securely lashed to the frames to prevent sagging, the frames being meanwhile additionally supported by two sets of back-guys, one at the top and the other half-way down. This being done, and the combined frames being lowered into their final positions, the men climb up to the summit, and get into position the fork transom at H, the latter being raised by means of the blocks attached to the tips of the standards; one end must be raised first and slewed into its fork beyond its final position, and then hauled back again when the other end has been got opposite its fork.

The upper of the two transoms at F must now be temporarily suspended about a foot above the level of the other main transoms. The tension spars (C) must then be got into position outside of the frames, and lashed to each other close under the upper transom and temporarily to the supporter standards. The lower of the suspended transoms at F is then, by means of the blocks above, got into position under the crossing of the tension spars, and supported by ropes arranged as slings. This is done by sending a 3 in. rope (one of the guy ropes will answer) up to the top on each side, passed over the fork transom, down underneath the suspended one, up again around the top one, and so on, until there are six or more parts supporting the lower one; the ends are then carefully secured together. The suspended transoms must bear equally on each bight of rope, and the ropes must not ride over each other.

The other transoms are then suspended temporarily from the crossing of the supporter standards and cross spars (D) by the tension spars. The other roadbearers are then placed, and the roadway laid as described further on.

The central slings are then tightened as follows, by what is known as a Spanish windlass: A handspike, or a small pointed spar, as shown in the drawings, is inserted between the ropes passing up and those passing down, and by turning the handle around the rope a number of times, using the thick end as a center, the rope is tightened as required, and the transoms brought to their proper positions. The handspike, or spar, is then secured to one of the tension spars by a lashing. Great care must be taken that the handspike, or spar, is not let go during the operation of twisting. The remaining transoms, which had been temporarily suspended from the intersection of the three spars on each side, are then secured by slings and tightened in the same manner as the central transoms. If cross transoms were placed above the crossing of the supporter standards and cross spars by the tension spars, the structure would be advantageously stiffened. If spars of sufficient size and length for the supporter standards are not easily procurable, compound spars, formed of three or more spars lashed together, could be used. The latter disposition is even advisable in cases where great weights are to be supported.

In building the roadway, the longitudinal bearers are got into position by men standing astride of the spars, facing the bridge, who launch them by gradually pushing and lifting them forward, being assisted in this by men on the opposite side, who haul on a breast-line made fast to the tip. The tip of the spars when they meet on the transoms should overlap.

The roadway should rise toward the center, the frames being certain to yield somewhat under heavy traffic. At the transoms, where the roadbearers cross, they should be all tips or all butts, in order that the planks have an even bearing.

The abutments are formed, as shown in Plate 2, of a shore transom, placed at a varying distance from the bank, say, from two to six feet, according to the nature of the ground, buried to half its depth, and firmly secured by pickets driven into the ground. On this transom the roadbearers rest; and to prevent the forcing of the earth between them by the wheels of vehicles, a plank is set on edge against their flush ends. From this latter a slope of earth, covered with planks if necessary, should be made to the level of the land roadway. The roadbearers being laid, the planks are placed, racked down as shown in the drawings, and the slings then finally tightened up. Handrail ropes are then attached to pickets on each side of the bridge, a clove hitch being made around the standards and other spars, and the bridge is finished. A spar roadway could be made instead of one of boards, the inequalities being filled with earth or clay.

The following is an estimate of the materials required for a bridge similar to the one described:

4 spars, 56 ft. long (7 in. at tip and 14 in. at butt), for supporter standards.

4 spars, 32 ft. long (14 in. throughout), for pier standards.

4 spars, 25 ft. long (6 in. throughout), for tension spars.

2 spars, 30 ft. long (6 in. throughout), for cross spars.

17 spars, 16 ft. long (9 in. throughout), for transoms and ledgers.

4 spars, 30 ft. long (4 in. at tip), for temporary diagonals of supporter frames.

15 spars, 30 ft. long (8 in. average diameter), for roadbearers.

80 planks, 11½ ft. long (1 ft. wide, and 3 in. thick), for roadway.

2 planks, 16 ft. long (1½ ft. wide, and 4 in. thick), for shore abutments.

6 split spars, 3 ft. long (8 in. diameter), for racking-down spars.

30 rack-sticks and lashings (8 ft. of 2 in. rope) for each stick.

10 guys (3 in. rope), 20 fathoms, for each guy.
4 foot ropes (3 in.), 6 to 9 fathoms each.
8 lashings (2 in. rope), 8 fathoms, for main transoms.
6 lashings (2 in. rope), 8 fathoms, for tension spars.
12 lashings (1½ in. rope), 5 fathoms, for ledgers.
10 lashings (1½ in. rope), 5 fathoms, for temporary diagonals.
20 lashings (1 in. rope), 3 fathoms, for roadbearers.
6 handspikes, 6 ft. long, if used for the Spanish windlass.
2 balls of spun yarn.
12 pickets, 5 ft. each
2 heavy wooden mallets.
6 single blocks, 5 in.
6 falls for blocks, 15 fathoms of 2 in. rope for each.
4 pick axes.
4 shovels.
2 measuring rods, 6 ft. each.
2 tracing tapes.
2 measuring tapes, 50 ft. each.
A lot of pickets.

COMPOSITION OF THE SWEET POTATO.

THE sweet potato (*Convolvulus batatas* or *Batatas edulis*) is an esculent of great value to the United States. It is not only at home in all the Southern States, but is produced in large quantities in Central New Jersey and Central Illinois, latitude 40°, and has been successfully raised in gardens in nearly the coldest parts of New York as well as in Maine and Southern Minnesota (St. Paul), in latitude 44° to 45°. It is probable that, under northern cultivation, varieties may originate more adapted to cold climates, so that, were it needful, its profitable cultivation might be extended several degrees of latitude northward, as is said to have happened in Europe with regard to maize, for which it is asserted that 46° north latitude was formerly the limit, whereas now it is cultivated nearly to 52°.

The sweet potato is known in many varieties, which differ widely in quality. Naturally, the kinds which are propagated at the North are less sweet and less highly flavored than those produced in a warmer climate. The New Jersey and Delaware sweet potatoes which are marketed in New England, though palatable and largely consumed, are decidedly inferior to the produce of Virginia. I am informed that sweet potatoes of excellent quality are raised in Southern Illinois, lat. 37°–38°, while those produced in Central Illinois, lat. 40°, are "watery" and comparatively insipid.

The sweet potato in highest repute at the North is the Nansemond, taking its name from the southeastern county of Virginia, where it is said to have originated. The "Nansemond Improved," raised in Hanover Co., Va., is the finest variety of this esculent that has come under my notice.

ANALYSIS OF SWEET POTATO.

Water	73·39
Starch, by difference	15·06
Gum	1·08
Sugar (levulose?)	6·86
Cellulose	0·98
Albuminoids	1·28
Fat and wax	·28
Ash	1·07
	100·00

In nutritive values the Hanover sweet potato and the common potato, on the average, differ but little. Their comparative composition is as follows:

	Sweet potato.	Potato.
Water	73·4	74·6
Albuminoids	1·3	2·2
Fat and wax	0·3	0·2
Carbohydrates	23·0	21·2
Fiber	1·0	0·7
Ash	1·0	1·1
	100·0	100·0

The sweet potato is possibly more easily digestible than the common potato, because of containing nearly 7 per cent. of soluble sugar in place of a similar amount of starch. Its sweet taste is mentioned by European writers as a reason why it does not enter more largely into the produce of southern France, and probably for most inhabitants of temperate regions it does not relish so well in constant use as does the common potato, which, like bread, appears daily and twice daily on the tables of the Middle and New England States,

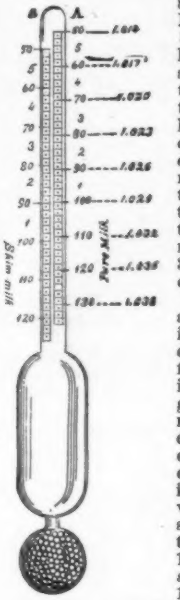
as well as on those of England, Germany, and France. The sweet potato is, however, in its best varieties, a most inviting esculent, and perhaps "wears" better than any other vegetable save the common potato. Its juices are so rich in sugar that the tuber keeps poorly, for wherever the cuticle is broken, the common omnipresent fungi take root, under favorable conditions of temperature and moisture, and rapidly penetrate the tissues, producing discoloration and dry or wet rot. French authorities report that the potato-fungus, *Peronospora infestans*, attacks the sweet potato as vigorously as the common.—*S. W. Johnson.*

THE ADULTERATION OF MILK.

By HENRY A. MOTT, Jr., E.M., Ph.D., of New York.

[Continued from page 1050.]

THE CENTESIMAL GALACTOMETER was invented by Dinocourt: it is shown in the figure. The stem of the instrument has two scales: one for pure milk, the other for skimmed milk; the scale A, *in part colored yellow*, serves to weigh the milk with its cream; the first degree on the top of the scale is marked 50, which corresponds to the sp. gr. 1·014. The following marks extend from 50 to 100 (sp. gr. 1·029), and over. Each degree starting from one hundred in mounting up to 50, represents a hundredth of pure milk; the degrees formed by a *line* are equal, as 50, 52, 54, etc.; the degrees formed by a dot are unequal, as 81, 83, 85, etc. To illustrate by an example: If the galactometer is sunk to the 85th degree, that will indicate 85 hundredths of pure milk, and consequently that 15 hundredths of water has been added to this milk; if sunk to 60 degrees, that will indicate 40 hundredths of water, or four-tenths of water added. If it is desired to count by tenths, it is only necessary to notice that the first tenth is white, that the second is colored yellow, the third white, the fourth yellow, and that the fifth is also white; towards the middle of each tenth the figures 1, 2, 3, 4, 5 are placed to indicate their order.



The scale, *a*, is in part colored blue, and is destined to weigh skim milk; it is, like the first, divided into hundredths (100 degrees), of which the first 50 have been cut off as useless, as in the case of the other scale, each degree commencing from 100 to 50 and mounting upwards represents a hundredth of pure skimmed milk, consequently the manner of estimating the quantity of water added to skim milk is absolutely the same as for pure milk with cream. The degree 130 corresponds to a specific gravity 1·038, the degree 120 to 1·035, the degree 110 to 1·032, *the degree* 100, *which is the standard, to* 1·029, the degree 80 to 1·023, the degree 70 to 1·020, the degree 60 to 1·017, and the degree 50 to 1·014.

ANOTHER CENTESIMAL GALACTOMETER* was invented by Chevallier; it is similar to the above instrument. It serves to determine the specific gravity of cream, milk, and skimmed milk. This instrument is used in connection with the creamometer. The specific gravity of the milk not skimmed is first determined, noting the temperature, then the volume of cream is ascertained by means of the creamometer, and finally the specific gravity of the skimmed milk is determined, noting the temperature.

From the data obtained, by referring to tables compiled by Chevallier, the additional water contents of the milk is ascertained.

THE LACTODENSIMETER.

The lactodensimeter† is an instrument differing from the galactometer just described only in the division of its scale. It is the production of Bouchardat and Quevenne, and is represented in the figure. This instrument, like all the densimeters, gives immediately and without calculation the density of the liquid in which it is plunged; its scale comprises only the densities which may be presented by pure or adulterated milk. The shaft bears three distinct graduations. The first, which is the middle one in the figures, contains the whole numbers intermediate between 14 and 42. In reality, the whole numbers comprised between 1·014 and 1·042 ought to be inscribed; but on account of the small size of the shaft the two first figures have been suppressed which do not change. If, consequently, the instrument is sunk in a liquid up to the figure 29, this signifies that a litre of this milk weighs 1·029 grams, and that its density is consequently 1·029. The instrument has been graduated for the temperature of + 15° C. It is necessary, therefore, for obtaining an *exact* indication, to be assured the liquid under examination is at this temperature. In the contrary case, it may be brought back to this degree by plunging the gauge containing the milk in water that is cold, or in lukewarm water, according as the thermometer is above or below + 15°. The table given below may also be employed, which is easily comprehended on inspection, and which is extracted from the memoir of Bouchardat and Quevenne.‡ The scale on the right is employed when it is certain that the milk acted on is not skimmed. This scale shows what are the variations of the density of milk in proportion as water is added, and the figures 1/10, 2/10, etc., indicates that the liquid operated upon has been mixed with this proportion of water. The scale on the left contains the same indications relative to skimmed milk. Milk is marked pure on this instrument, between the specific gravities 1·030 and 1·034, skimmed milk is marked pure between the gravities 1·034 and 1·037.

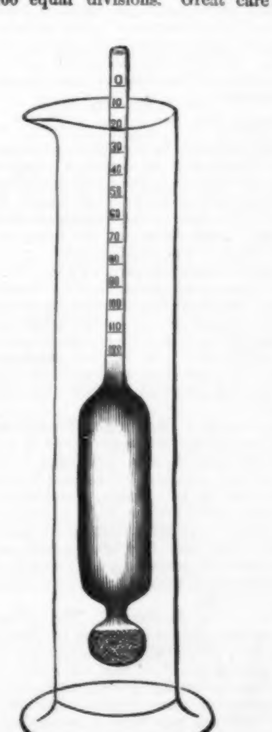
LACTOMETERS.

The original lactometer was discovered by Prof. Edmund Davy§ in 1821. It is represented in the figure. It is made of brass, and consists of a pear-shaped bulb, at the top of which is a graduated stem, and at the bottom a brass wire, to the end of which a weight is screwed. This instrument is only intended for skimmed milk, and the 0 mark corresponds to the sp. gr. 1·035, which, according to Davy's experiments, represents the lightest genuine skimmed milk. The dots in the figures, which extend from 0 to 35, indicate parts of water in 100 parts skimmed milk at 60°.

Who invented the lactometer for *testing milk* I am unable to ascertain; one thing is certain, however: the one who first divided the scale from 0 water to 100 pure milk was, of course, the inventor. Of the various lactometers that have been in use, the only difference was the specific gravity represented by the 100 degree of the scale. The specific gravity corresponding to the 100 degree on the centesimal galactometer invented by Dinocourt, as I have already stated, was 1·029, which was intended to represent the proper minimum. This sp. gr. has been adopted by the Board of Health of New York as the standard for their lactometers.

The old standard adopted by the milk dealer was 1·030; this was changed by Dr. Chilton to 1·034, and has gradually dropped to 1·033. So that the standard now employed by the milk dealers to *secure for themselves* pure milk is 0·004 higher than that adopted by the Board of Health.

In graduating the Board of Health lactometer shown in the figure, the 100° is placed at the standard 1·029, and 0 at 1·000, the gravity of water, the intermediate spaces being divided into 100 equal divisions. Great care should be taken to determine with absolute accuracy the 0 degree and the 100 degree; other points may also be determined, but they are not absolutely necessary if the space is properly divided. The point to which the lactometer sinks in the milk under examination indicates the percentage of milk in 100 parts. Thus, if the lactometer sinks to 80, the milk must consist of, at least, 20 per cent. of water and 80 of milk. This assumes the original milk to have had a specific gravity of 1·029; but, if the milk had originally a gravity of 1·034, it would require 16·67 per cent. of water to bring it down to 1·029, and 20 per cent more water to lower it to 80° on the lactometer. The temperature at which examinations are made with the lactometer should be 60 F., for *exact* determinations, as the instrument is graduated for that temperature. If it is only necessary to establish the *fact* of an adulteration by water, the milk may be cooled to a temperature below 60° F., which an expert can easily ascertain by the sense of taste, etc.—the lower the milk is cooled the more dense it becomes; consequently, if the lactometer should sink below 100 in a sample of milk known to be below 60° F., sufficient evidence to establish the *fact* of its adulteration is indicated. A sample of milk tested by Dr. Chandler,* which stood at 100 by the lactometer at 60° F., was found to stand at 106 at 44° F., at 98 at 66° F., at 90 at 80° F., and at 74 at 100° F.



°	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
14	12.9	12.9	12.9	13.0	13.0	13.1	13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	14.0	14.1	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8
15	13.9	13.9	13.9	14.0	14.0	14.1	14.1	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	15.0	15.1	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8
16	14.9	14.9	14.9	15.0	15.0	15.1	15.1	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	16.0	16.1	16.3	16.5	16.7	16.9	17.1	17.3	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9
17	15.9	15.9	15.9	16.0	16.0	16.1	16.1	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	17.0	17.1	17.3	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	20.0
18	16.9	16.9	16.9	17.0	17.0	17.1	17.1	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	18.0	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	21.0
19	17.8	17.8	17.8	17.9	17.9	18.0	18.1	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	19.0	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	22.0
20	18.7	18.7	18.7	18.8	18.8	18.9	19.0	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.8	20.0	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7	23.0
21	19.6	19.6	19.7	19.7	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.1
22	20.6	20.6	20.7	20.7	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.8	22.0	22.2	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.1	24.3	24.5	24.7	24.9	25.2
23	21.5	21.5	21.6	21.7	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2	24.4	24.6	24.8	25.1	25.3	25.5	25.7	26.0	26.3
24	22.4	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.8	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.1	26.3	26.5	26.7	27.0	27.3
25	23.3	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1	24.2	24.3	24.5	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.0	26.2	26.4	26.6	26.8	27.1	27.3	27.5	27.7	28.0	28.3
26	24.3	24.3	24.4	24.5	24.6	24.7	24.8	24.9	25.0	25.1	25.2	25.3	25.5	25.6	25.8	26.0	26.2	26.4	26.6	26.9	27.1	27.3	27.5	27.7	27.9	28.2	28.4	28.6	28.9	29.2	29.5
27	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0	26.1	26.2	26.3	26.5	26.6	26.8	27.0	27.2	27.4	27.6	27.9	28.2	28.4	28.6	28.8	29.0	29.3	29.5	29.7	30.0	30.3	30.6
28	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9	27.0	27.1	27.2	27.4	27.6	27.8	28.0	28.2	28.4	28.6	28.9	29.2	29.4	29.6	29.9	30.1	30.4	30.6	30.8	31.1	31.4	31.7
29	27.0	27.1	27.0	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.1	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.9	30.2	30.4	30.6	30.9	31.2	31.5	31.7	31.9	32.2	32.5	32.8
30	27.9	28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	29.0	29.2	29.4	29.6	29.8	30.0	30.2	30.4	30.6	30.9	31.2	31.4	31.6	31.9	32.2	32.5	32.7	33.0	33.3	33.6	33.9
31	28.8	28.9	29.0	29.1	29.2	29.3	29.5	29.6	29.7	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.7	32.0	32.3	32.5	32.7	33.0	33.3	33.6	33.8	34.1	34.4	34.7	35.1
32	29.7	29.8	29.9	30.0	30.1	30.3	30.4	30.5	30.6	30.8	31.0	31.2	31.4	31.6	31.8	32.0	32.2	32.4	32.7	33.0	33.3	33.6	33.8	34.1	34.4	34.7	34.9	35.2	35.5	35.8	36.2
33	30.6	30.7	30.8	30.9	31.0	31.2	31.3	31.4	31.6	31.8	32.0	32.2	32.4	32.6	32.8	33.0	33.2	33.4	33.7	34.0	34.3	34.6	34.9	35.2	35.5	35.8	36.0	36.3	36.6	36.9	37.3
34	31.5	31.6	31.7	31.8	31.9	32.1	32.2	32.3	32.5	32.7	32.9	33.1	33.3	33.5	33.8	34.0	34.2	34.4	34.7	35.0	35.3	35.6	35.9	36.2	36.5	36.8	37.1	37.4	37.7	38.0	38.4
35	32.4	32.5	32.6	32.7	32.8	33.0	33.1	33.2	33.4	33.6	33.8	34.0	34.2	34.4	34.7	35.0	35.2	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.1	39.5

Value of the Degrees of the Board of Health Lactometer in Specific Gravity.—By Dr. Waller.

Lactometer.	Gravity.	Lactometer.	Gravity.
0	1·00000	61	1·01769
1	1·00029	62	1·01798
2	1·00058	63	1·01827
3	1·00087	64	1·01856
4	1·00116	65	1·01885
5	1·00145	66	1·01914
6	1·00174	67	1·01943
7	1·00203	68	1·01972
8	1·00232	69	1·02001
9	1·00261	70	1·02030
10	1·00290	71	1·02059
11	1·00319	72	1·02088
12	1·00348	73	1·02117
13	1·00377	74	1·02146
14	1·00406	75	1·02175
15	1·00435	76	1·02204
16	1·00464	77	1·02233
17	1·00493	78	1·02262
18	1·00522	79	1·02291
19	1·00551	80	1·02320
20	1·00580	81	1·02349
21	1·00609	82	1·02378
22	1·00638	83	1·02407
23	1·00667	84	1·02436
24	1·00696	85	1·02465
25	1·00725	86	1·02494
26	1·00754	87	1·02523
27	1·00783	88	1·02552
28	1·00812	89	1·02581
29	1·00841	90	1·02610
30	1·00870	91	1·02639
31	1·00899	92	1·02668
32	1·00928	93	1·02697
33	1·00957	94	1·02726
34	1·00986	95	1·02755
35	1·01015	96	1·02784
36	1·01044	97	1·02813
37	1·01073	98	1·02842
38	1·01102	99	1·02871
39	1·01131	100	1·02900
40	1·01160	101	1·02929
41	1·01189	102	1.02958
42	1·01218	103	1·02987
43	1·01247	104	1·03016
44	1·01276	105	1·03045
45	1·01305	106	1·03074
46	1·01334	107	1·03103
47	1·01363	108	1·03132
48	1·01392	119	1·03161
49	1·01421	110	1·03190
50	1·01450	111	1·03219
51	1·01479	112	1·03248
52	1·01508	113	1·03277
53	1·01537	114	1·03306
54	1·01566	115	1·03335
55	1·01595	116	1·03364
56	1·01624	117	1·03393
57	1·01653	118	1·03422
58	1·01682	119	1·03451
59	1·01711	120	1·03480
60	1·01740		

The following table by De Voelcker, with an addition by Dr. Chandler,* illustrates the effects of watering and skimming:

	UNSKIMMED.		SKIMMED.	
	Sp. Gr.	Lact.	Sp. Gr.	Lact.
Pure milk ...	1·0314	108	1·0337	117
10 per cent. water added	1·0295	102	1·0308	106
20 " " "	1·0257	88	1·0265	91
30 " " "	1·0233	80	1·0248	86
40 " " "	1·0190	66	1·0208	72
50 " " "	1·0163	56	1·0175	60

* Johnson's Encyclopædia—article "Milk."

* Jour. Pharm. et Chem., 3d series, 1844, t. v. p. 137; Jour. Chem. Medic., 4th series, 1856, t. 11, p. 342–401.
† See Dic. Ency. Sci. Med., p. 144—Lait.
‡ Répertoire de Pharmacie, juillet, 1856.
§ Tilloch's Philosophical Magazine, No. 57, 58, p. 241.

Thus it is seen that with a sample of pure milk of sp. gr. 1·0314 more than 10 per cent. of water could be added before the gravity is reduced to 1·029 or 100 on the lactometer; and, after skimming, considerable more.

That the specific gravity 1·029 is the true minimum standard for *pure whole cow's milk*, I think I have already fully demonstrated, yet it is interesting to bear in mind that it has been confirmed by "Müller,* Fleischmann, Goppelsroeder, Krämer, and other *specialists*."

Müller† says: "From more than 6,000 notes by Quevenne and Bouchardat, the minimum is 1·029, and the maximum 1·033. For the hospitals and public institutions in Paris, the minimum is 1·030." He further says: "If," . . . "we go through all Europe, from country to country, from place to place, from dairy to dairy, from Alp to Alp, with the lacto-densimeter in hand, and mix at times the milk of several cows together which have been milked under conditions sufficiently touched upon, we shall find that the milk which is divided as a trade commodity from the physiological milk weighs between 1·029 and 1·033."

Let us consider, now, if there are any objections to the use of the standard lactometers for the detection of adulteration. I have already stated that a sample of perfectly pure cow's milk, possessing a high specific gravity, can be considerably additioned with water, and the lactometer is unable to detect the fraud. The question naturally arises, is there any method by which the fraud can be detected? The answer comes, unfortunately, *no*—owing to the variation in the proportion of each constituent, a proper margin has to be left for the maximum and minimum proportions, and between these limits the fraud can be perpetrated, and defy all Science to detect it.

Milk may be skimmed, which will increase the specific gravity of the fluid; it may then be watered, and the sp. gr. reduced to the standard of the lactometer, or the sp. gr. may be still further reduced, and by the addition of some solid substance, such as sugar or salts, increased to the standard specific gravity. The question naturally arises here, can the lactometer detect such adulteration? To answer this question, we must first inquire into the method adopted, where the lactometer is used to detect adulteration. It is to be supposed that an expert commissioned to examine milk for adulteration, using, as a means, the lactometer, will perform the test which is to be made, in connection with the senses—that is to say, the sample under examination should be examined as to its opaqueness and color, its taste and odor, etc. If, on the contrary, he performs the test automatically, simply taking the degree of the instrument, noting the temperature, without examining the sample otherwise—the lactometer itself will not detect such adulteration; but such an experimenter is not fit or competent to make such investigations, for, no matter what the method of examination may be, the common sense is always required to accomplish the object in view. I say it *without fear of successful contradiction*, that if the lactometer is used in connection with the senses, that is to say, regarding the flow of milk from the bulb of the instrument, observing its opacity and color, as also examining as to flavor and odor of the sample under examination, that the lactometer will detect all the *practical frauds* perpetrated *by milkmen*. In my opinion there is not one unprejudiced person, with the experience and education that a milk expert should have, that cannot distinguish a fair sample of pure milk from a fair sample of skimmed milk or cream; and, if such is the case, how readily could be detected an adulterated sample.

In the first part of this paper I stated that the indications of the lactometer are infallible; this is the case, for if a sample of milk should indicate a degree less than the standard, there is indisputable evidence that the sample has been tampered with.

(*To be continued.*)

DEUTSCHE CHEMISCHE GESELLSCHAFT, BERLIN.

March 12.

Prof. A. W HOFMANN, F.R.S., Vice-President in the chair.

AT the opening of the session, Prof. Hoffman paid a short tribute to the memory of Frederick Varrentrapp, whose death at Brunswick, in his sixty-second year, has lately been announced. Varrentrapp rendered his chief services to chemistry in his younger years, and his name is best known as associated with that of Liebig's in extensive researches on the fatty series, and with that of Will in the familiar apparatus for the determination of nitrogen in organic bodies. Of late years he had devoted himself almost exclusively to industrial chemistry.

Prof. Oppenheim delivered an address upon the late Brussels Exhibition of Life-saving Apparatus, etc., in its chemical connections.

Prof. Liebermann and F. Giessel described "Some Derivatives of Chinizarin." The preparation from pheno chloride and phthalic anhydride has been found to yield the best results. By the action of hydriodic acid and phosphorus as reducing agents chinizarin—

$$C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_2(OH)_2,$$

gave as the first product—

$$C_6H_4\left\{\begin{matrix}C(OH)H\\C(OH)H\end{matrix}\right\}C_6H_2(OH)_2$$

crystallizing in the form of yellow needles, dissolving in alkalies with a yellow color, and capable of being changed back to chinizarin by simple exposure to the oxidizing effect of the air. The second product is—

$$C_6H_4\left\{\begin{matrix}C(OH)H\\CH_2\end{matrix}\right\}C_6H_2(OH)_2$$

also consisting of yellow needles, and the third and final product—

$$C_6H_4\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right\}C_6H_2(OH)_2,$$

which is obtained pure in the form of the potassium salt, possesses a slightly acid reaction, and shows all the properties of a phenol. Although not entering into combination with ammonia, it dissolves easily in ethylamin, forming—

$$C_6H_4\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right\}C_6H_2\left\{\begin{matrix}N(C_2H_5)H\\OH\end{matrix}\right.$$

which separates out in the form of yellow needles. Oxidation changes into—

$$C_6H_4\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right\}C_6H_2<{}^{O}_{O}>O.$$

* Anleitung zur Prüfung der Kuhmilch, p. 42.

† Correspondenz-Blatt des Niederrheinischen Vereins für oeffentliche Gesundheitspflege. Band vi., p. 88. Dr. Heusner.

A. Michael and T. H. Norton described a new acid, "Diamido-sulpho-benzide-dicarbonic acid,"

$$SO_2<\begin{matrix}C_6H_3<{}^{NH_2}_{COOH}\\C_6H_3<{}^{COOH}_{NH_2}\end{matrix}$$

obtained by the action of weak fuming sulphuric acid upon paramido-benzoic acid at 170°. It does not melt below 350°, and crystallizes easily from water, but is not easily soluble in alcohol, ether, and other solvents. It forms with sulphuric acid a very soluble compound, and yields finely crystallizing metallic salts, those with lead and silver being especially insoluble. This is the first sulphon containing a carboxyl group, which has been so far prepared, and was obtained under very nearly the same conditions by which metamido-benzoic acid yields a sulphonic acid. The authors found in the preparation of paramido-benzoic acid, from para-nitro-toluen, that a very dilute solution of potassium permanganate was much better adapted for purposes of oxidation than the methods hitherto in use. During the process of reduction with tin and hydrochloric acid it was also observed that paramido-benzoic acid, when heated with $SnCl_2$ at 120°, was entirely decomposed into carbonic acid and aniline.

A. Michael and A. Adair gave the results of experiments on the formation of "Aromatic Sulphons," leading to the adoption of the following as a general method of preparation. If sulphonic acid be mixed with an excess of an aromatic hydrocarbon and phosphoric anhydride, and heated in a closed tube for a number of hours at 150° to 200° the corresponding sulphon is formed, although in not very large quantities. Experiments were tried with benzen-sulphonic acid and toluen, para-toluen-sulphonic acid and toluen, and para-toluen-sulphonic acid and benzen. The mixed sulphons of benzen and naphthalin obtained in this way were studied more particularly. Benzen-sulphonic acid and naphthalin yield two isomeric sulphons with the formula—

$$SO_2<{}^{C_6H_5}_{C_{10}H_7}$$

The α-sulphon melts at 100°, and forms white rhomboidal crystals. The β-sulphon separated from the other by treatment with alcoholic ether melts at 115°, and crystallizes in needles. Benzen and β-naphthalin-sulphonic acid yield a single sulphon, coinciding in properties with the β-sulphon from benzen-sulphonic acid. The isomers are both very insoluble in water. The identity of the compounds obtained by the two processes furnishes additional strength to the theoretical considerations with regard to the hexavalence of sulphur in sulphuric acid.

W. Klobukowski communicated the results of experiments "On the Constitution of Rufigallic Acid." An acetyl compound was prepared, and shown by analysis to be a hexacetyl rufigallic acid. By treatment with methyl iodide and ethyl iodide in the presence of potassic hydrate at 130° tetramethyl and tetra-ethyl derivatives of rufigallic acid were obtained, which, upon further treatment with the iodides, were changed into the hexa compounds. All of these derivatives possess remarkably fine crystalline forms. They are regarded by the author as proofs of the existence of six hydroxyl groups in rufigallic acid, and as this acid, as well as the compounds obtained by him from it, yield anthracen directly by reduction with zinc, he considers it to be a hexa-oxy-anthraquinon. The formation from gallic acid would then be as follows:

$$2C_6H_2(OH)_3COOH=2H_2O+OC[C_6H(OH)_3]_2CO.$$

The following papers have been communicated by non-resident members:

H. Limpricht, "Replacement of Br and SO_3H by H in the Benzen-sulphonic Acids." The author has studied various reactions adapted for the reduction of the more highly substituted benzen derivatives to simpler forms, with the view of controlling their proposed rational formulæ. Concentrated HCl and phosphorus are found to be the best reagents for the gradual replacement of bromine by hydrogen in such compounds. Amido-benzen-sulphonic acid, $C_6H.Br_3.NH_2.SO_3H$, subjected to this treatment for several hours at 140° yields a mixture of

$$C_6H_2.Br_2.NH_2.SO_3H,$$
$$C_6H_3Br.NH_2.SO_3H, \text{ and } C_6H_4.NH_2.SO_3H.$$

The methods hitherto in use have produced an entire reduction, and have not permitted a study of the possible intermediate products. In most substituted benzen-sulphonic acids SO_3H can be replaced by H simply by heating with concentrated HCl, the bromo-benzen sulphonic acids being changed into bromo-benzens, the brom-amido-benzen-sulphonic acids into bromo-anilines, etc.

H. Bahlmann has prepared a number of "Derivatives of Ortho-amido-benzen-sulphonic Acid." Among these are the mono-bromo- and dibrom-amido-benzen-suphonic acids, and the orthiodo-, orthochloro-, and ortho-bromo-benzen-sulphonic acids. From the latter a nitro-bromo-benzen-sulphonic acid, $C_6H_3.NO_2.Br.SO_3H$ (1, 4, 5), was obtained by treatment with HNO_3. A number of salts and the amido-bromo-benzen-sulphonic acid obtained by reduction with tin and HCl are described.

B. Radziszewski, "On some Phosphorescent Organic Bodies." Grape-sugar, when dissolved in an alcoholic solution of caustic potash, and submitted to the action of a stream of oxygen, exhibits the same phenomenon of phosphorescence shown by lophin, paraldehyd, furfurin, and other polymeric aldehyds or NH_3 derivatives of aldehyds, when exposed to oxidizing influences under the same circumstances. This fact furnishes additional proof for the aldehyd nature of grape-sugar. Formic aldehyd exhibits also phosphorescence under similar conditions while changing into formic acid.

A. Baeyer, "On Furfurol." The author has obtained previously among the condensation products of furfurol and various phenols, green substances strongly resembling chlorophyll. Experiments show that the color is not due to the presence of an aromatic group, as furfuric alcohol itself gives the coloration when treated with HCl. In pursuing the subject furfurol was treated according to Perkin's reaction, with acetic anhydride and sodium acetate. The result was furfuracrylic acid:—

$$C_4H_3O.CHO+CH_3.CO.OH=$$
$$=C_4H_3O.CH.CH.COOH+H_2O.$$

The new acid, which is isomeric with salicylic acid, melts at 135°, possesses a cinnamonic odor, and is volatile. Concentrated HCl dissolves it under formation of a stable green color, and H_2SO_4 yields a green condensation product. Reduction with sodium amalgam yields furfur-propionic acid, $C_7H_8O_3$, melting at 50°, forming with HCl a reddish yellow solution, possessing the odor of furfuracrylic acid, but much more soluble in water.

W. Weith, in the course of experiments "On the Constitution of Carbo triphenyl-triamine," finds that the following is the only decomposition resulting from treatment with HCl or HKO:

$$CN_3H_2(C_6H_5)_3+2H_2O=CO_2+3C_6H_5NH_2,$$

that H_2SO_4 neither gives the bright blue color peculiar to bodies containing $N(C_6H_5)_2$, nor forms diphenyl-amin sulphonic acid, yielding instead sulphanilic acid, that carbo triphenyl triamine is not changed under any circumstances to α-triphenyl guanidin, and that it finally by distillation is decomposed into aniline, ammonia, hydrocyanic acid, diphenylamin and benzonitrile. From these facts he regards carbo-triphenyl-triamine as a symmetrical triphenyl guanidin—

$$\begin{matrix}NHC_6H_5\\CNC_6H_5\\NHC_6H_5\end{matrix}$$

C. Böttinger, "Action of Ammonia and Amido Derivatives upon Pyroracemic Acid." Alcoholic ammonia yields a new acid, $C_8H_9NO_4$, which has been named uvitoninic acid. By the action of anthranilic acid upon pyroracemic acid a mixture of condensation products was obtained.

E. Mulder, "On the Mono-molecular Unit of Volume for Gases and Vapors." The author favors from various theoretical considerations the adoption of 0·5 as the atomic weight of hydrogen, in order to give more simplicity to the expression for Avogadro's law, replacing $M=2\delta$ by $M=\delta$.

H. W. Vogel, "Spectroscopic Notes." The author has discovered that thin sections of garnets yield quite distinct absorption spectra, consisting of a broad band in the green portion of the spectrum, between *b* and F, a less prominent one between D and E, and a weak one between E and *b*. Ruby displays a single band between E and D. It is suggested that this property be made use of for the detection of the precious stones. In order to remove the alkaline bands apparent in the spectrum of purpurin when dissolved in pure water before proceeding to test for magnesia, the addition of a few drops of chloride of ammonium is found sufficient. The use of potassic tartrate for the precipitation of lime from solutions to be tested for Mg is regarded unfavorably on account of the frequent presence of Mg in the tartrate; precipitation with ammonium chloride and carbonate is preferred. In order to test for aluminium by the purpurin reaction, when iron salts are present, the latter are oxidized, the solution is treated with KSCN, and the ferric sulphocyanide thus formed is removed by shaking with ether.

K. Stuckenberg, "On Benzoyl Derivatives of Orthopara-amido-phenol." The hydrochlorate of this α-diamido-phenol, when treated with benzoyl-chloride, yields tribenzoyl-α-diamido-phenol—

$$C_6H_3.N(CO.C_6H_5)_2.NH(CO.C_6H_5).OH,$$

and dibenzoyl-α-diamido-phenol—

$$C_6H_3.(NH.CO.C_6H_5)_2.OH.$$

The latter crystallizes in triclinic columns, which show all the peculiar properties of felspar in polarized light.

"On α-Amido nitro-phenol, its Benzoyl Derivative, and an Amido-dinitro-phenol." The author obtains α-amido nitro-phenol from α-dinitro-phenol by subjecting the alcoholic solution to the action of H_2S and $NH_4.SH$. By treatment with benzoyl-chloride, benzoyl-α-amido-nitro phenol was obtained, and from this by the action of HNO_3 the author prepared nitro-benzoyl-α-amido-nitro-phenol, $C_6H_2.(NO_2)_2.NH(CO.C_6H_5).OH$, which, by reduction, gives an amido dinitro-phenol—

$$C_6H_2.(NO_2)_2.NH_2.OH,$$

apparently indentical with picraminic acid.

"On β-diamido-Phenol, its Benzoyl Derivatives, and β-amido-nitro-phenol." β-diamido-phenol results from the reduction of diortho nitro-phenol with Sn and HCl. Treatment with benzoyl chloride yields a mixture of dibenzoyl, tribenzoyl, and tetrabenzoyl β-diamido-phenol. β-amido-nitro-phenol is obtained from β-dinitro-phenol by the action of H_2S and $NH_4.SH$.

ATOMIC WEIGHT OF SELENIUM.

PETTERSSON and EKMAN have made an extended research on the atomic weight of selenium, analyzing for this purpose calcium, magnesium, and silver selenates, ammonium aluminum selenate, silver selenite, and selenous oxide, all of the greatest attainable purity. Silver selenite on ignition yields a beautiful crystalline crust of pure silver. Hence by weighing the salt, igniting and again weighing, the data for determining the atomic weight are obtained. As a mean of seven analyses, the atomic weight obtained was 79·01. By reduction of selenous acid by sulphurous acid, collecting and drying the precipitate and weighing it, another determination was made. The mean of five determinations, which agree well with each other, is 79·08. The authors, believing the latter determination to have more weight, assign the atomic weight 79·08 to selenium, which they believe correct to the first decimal place.—*Berl. Chem. Ges.*

CACHOU DE LAVAL.—According to a series of experiments lately executed, this patent color gives very valuable results. Fifty grammes (1¾ oz.) of the color to 35 fluid ounces of water, give a very useful shade. The fixing bath to follow after consists of 75 grains bichromate per 35 fluid ounces of water. A dye bath containing only 45 grains of color to 35 oz. water, and a subsequent passage through chromate of potash, give a light gray with a yellowish cast. If 150 grains of the patent color are dissolved in water, and mixed with ¾ oz. catechu, previously dissolved in 150 grain measures of caustic soda lye of specific gravity 1·208, and 17 oz. water, and the whole made up with water to 35 oz. cotton yarn, when worked in this liquid for 15 minutes at 167° F., and then taken through a chrome beck, takes a deep, full bronze. The shade is deeper if taken through weak aquafortis at 2° B., instead of chrome. The tone of these colors is very pleasing. The "patent color" can also be advantageously combined, giving a full catechu tone with a strong reddish cast, especially if taken subsequently through aquafortis. The fixing bath has a great modifying influence upon the resulting color; bichromate of potash gives, as a general rule, the darkest tones; nitric acid and nitrate of iron give a yellowish gray, whilst a weak bluestone beck, say a ¼ oz. to 35 fluid ounces of water, give a gray with a blue shade; hence, the "patent color" may serve as a cheap ground for indigo. For this purpose the white yarn is first dyed with cachou de laval (45 to 75 grains of color per 35 fluid ounces of water), then taken through the bluestone beck, washed, dried, and topped in the vat in the ordinary manner. There is thus a considerable saving of indigo, without impairing the fastness of the color.—*Dingler's Polytechnic Journal.*

CHEMICAL SOCIETY, LONDON.

March 15, 1877.

Professor ABEL, President, in the chair.

"ON Isomeric Nitroso-Terpenes," by Dr. W. A. Tilden and Mr. W. A. Shenstone. After alluding to the former paper by Dr. Tilden on the same subject, the authors described the methods they now employ for the preparation of the nitroso-chlorides of the terpenes, and which consists in passing gaseous nitrosyl-chloride into a well-cooled mixture of the terpene with chloroform or with ordinary spirit, when the new compounds usually separate in the crystalline state. In this manner nitroso-chlorides have been obtained with the terpenes from both dextro- and lævo-gyrate turpentine oils, from oil of sage, and from oil of juniper; it is an important fact that although all these terpenes differ widely in their action on polarized light and in their other physical properties, yet the nitroso-derivatives, obtained by the action of alcoholic potash on the nitroso-chlorides, are all without action on polarized light, melt at the same temperature, and agree apparently very closely in their crystalline forms. The nitroso-chlorides of that class of terpenes, boiling at about 175°, of which hesperidene, from orange peel oil, is a type, were also examined; crystalline compounds being obtained from hesperidene, oil of caraway, bergamot, and with some difficulty from essence of lemon. The nitroso-chlorides from the two first when carefully heated in small quantities at a time yielded crystalline nitroso-derivatives, although none could be obtained by the process found to answer so well with the terpenes of the first class, namely, treatment with alcoholic potash. The authors believe that this method will not only serve to discriminate the different isomeric terpenes, but also to show that a large number of the natural terpenes are merely physical isomerides and not distinct chemical compounds.

Professor Maskelyne said he was engaged in examining the crystalline forms of the substances described in this paper, but the investigation was not yet completed. He might say, however, that the crystals from the first group of terpenes, although at first sight they appeared very different, seemed really to belong to one and the same system. The crystals from hesperidene and caraway were very simple, and had very few faces to them, but he believed they belonged to a different system from the other group.

"Preparation of Copper-Zinc Couples," by J. H. Gladstone and Mr. A. Tribe. The object of the numerous experiments detailed in this paper was to ascertain the best formula for the preparation of the couple; and for this purpose it was necessary to ascertain the influence exerted both by the proportion of copper deposited on the zinc foil, and also by its state of aggregation, the latter varying with the strength of the solution of copper sulphate employed to attack the zinc. The results showed that the couple of maximum activity was obtained by depositing the copper from a 2 per cent. solution of the sulphate in six successive depositions, if it was to be employed in the decomposition of water, or for preparing ethyl hydride from a mixture of alcohol and ethyl iodide. For dry couples, however, such as those used in the preparation of the organo-zinc compounds and similar reactions, one deposition from a 2 per cent. solution was found to be most effective. The activity of these couples, from the results of experiments instituted with that object, was ascertained to be more than 1,000 times greater than that of pure zinc. This paper was illustrated by numerous experiments.

In reply to a question by Dr. Wright as to whether other copper salts had been tried for the preparation of the couple, and, if so, whether the conditions of maximum activity were the same:

Dr. Gladstone said experiments had been made with other salts of copper, but not quantitatively, the object being to ascertain the best way of making the most active couple, therefore copper sulphate had been used as being most convenient.

Mr Kingzett said that Dr. Paul, who had used the copper-zinc couple for estimating nitrates and nitrites in water, had found a great difference in the results obtained with couples prepared with solutions of copper sulphate of different strengths.

"Chromium Pig Iron," by Mr. E. Riley. A quantity of pig iron, which has recently been made in Australia, instead of having the ordinary qualities of pig iron, was found to be exceedingly hard, and to present the appearance of the specimen exhibited. The ore employed in the manufacture had been analyzed in this country by six or seven different chemists, all of whom, with one exception, had overlooked the presence of chromium, which might perhaps be accounted for by the fact that the specimen of ore sent over contained but a mere trace of chromium. The pig iron from this ore, however, contained 6 to 7 per cent. of chromium, as might be seen from the analysis given of two samples:

	I.	II.
Chromium	6·984	6·287
Carbon	4·418	4·200
Silicon	1·460	0·976
Sulphur	0·102	0·207
Phosphorus	nil	0·055
Iron	—	88·343
Manganese	0·125	nil

From this it could readily be seen that the relation between the amount of carbon and sulphur was quite abnormal. As some 1,200 tons of this iron had been manufactured, it was important to know what to do with it. It had been stated that chromium plays the same part as manganese in iron, but in experiments made to ascertain if this chromium pig iron could be substituted for spiegeleisen in the manufacture of Bessemer steel, very unsatisfactory results were obtained, the steel breaking up under the hammer. When mixed with one-half hæmatite and puddled, it melts with difficulty, but, although the chromium soon goes out in the cinder, the iron produced would not weld.

The President said Mr. Riley's communication possessed considerable interest, but he himself should have considered it very unlikely that this chromium iron would play the part of spiegeleisen. He had examined a specimen of the so-called chromium steel, but had found a mere trace of chromium in it. It was possible, however, that the chromium exerted a function in the production of the steel, but was eliminated at some stage in the process, so that it did not appear in the finished steel.

Mr. Riley, in answer to some remarks on the subject, expressed his opinion that the color test, although it could be depended on for the determination of the amount of carbon in steel, was very untrustworthy when applied to iron, the determination of the carbon by combustion after removal of the iron being the most reliable. He had found that the chromium had dissolved with the iron during the ordinary treatment for analysis.

"Note on Gardenin," by Dr. J. Stenhouse and C. E. Groves. Gardenin was discovered by one of the authors some twenty years ago in "Dekamali gum," an Indian drug, but the quantity obtained at that time was too small for analysis. Recently, however, they have obtained a larger specimen of the resin and extracted the gardenin from it. It crystallizes in deep yellow needles, which melt at about 164°, and are somewhat difficult to purify. The results of the analysis agree very well with the formula $C_5H_5O_2$, which requires 61·86 per cent. carbon and 5·15 hydrogen, whilst the numbers obtained by Flückiger were 59·47 carbon and 6·71 hydrogen. It is probable, however, that the specimen he analyzed, and which melted at 155°, was contaminated with a colorless fatty substance of low melting-point present in the resin, and which is not entirely removed even by repeated crystallization from spirit. The authors find when gardenin is dissolved in glacial acetic acid, and carefully treated with nitric acid in the cold, that a red crystalline substance is formed which melts at about 236°. It crystallizes in long needles, which are insoluble in water, and almost insoluble in alcohol. As it is insoluble in dilute acids, but soluble in dilute alkaline solutions, from which it is re-precipitated on the addition of an acid, it has been provisionally named gardenic acid. The authors hope soon to be in possession of a large quantity of dekamali gum, which will enable them to continue this investigation. A note on ginger was appended to this paper, in which it is shown that the resin in ginger when fused with an alkaline hydrate yields proto-catechuic acid.

The Secretary read two papers by Mr. M. M. P. Muir, the first of which was an "Additional note on a Process for Estimating Bismuth Volumetrically," in which the author gives a modification of his former process; he now precipitates the acid solution of bismuth nitrate with excess of sodium acetate, dissolves the precipitate by means of a slight excess of acetic acid, and titrates with a standard solution of potassium dichromate. The second paper was "On Certain Bismuth Compounds, Part IV.," in which a chromate of bismuth, $3Bi_2O_3,2CrO_3$, is described as obtained by the action of a hot potash solution on the chromate, $3Bi_2O_3 7CrO_3$. The formation of the compounds $Bi_2O_5 xH_2O$ and $Bi_2O_4 xH_2O$, by the action of chlorine on bismuthous oxide suspended in a hot solution of potassium hydrate, is then considered, and it is also shown that the oxide, Bi_2O_5, H_2O, when dissolved in an acid and precipitated with an alkali, always yields bismuthous hydrate, $Bi_2O_3 xH_2O$, whether the solution has been previously subjected to the action of reducing agents or not. The author concludes this part of his paper by discussing the formulæ of the six known hydrates of bismuth. There is an addendum on the action of potassium ferrocyanide on bismuth solutions, from which it appears that in presence of nitric acid bismuth ferrocyanide, Bi_45FeCy_6, is first produced, quickly passing, however, into the ferricyanide, $Bi_2,5FeCy_6$, which, in turn, undergoes decomposition with evolution of hydrocyanic acid.

NEW METHOD OF PRODUCING NITROGEN.

By J. W. GATEHOUSE.

WHEN binoxide of manganese is heated with ammonium nitrate, a violent action occurs, and if the external temperature is maintained the action may become so intense as to raise the contents of the vessel to dull redness, when abundance of the red vapors of nitrogen tetroxide are evolved.

The action begins at a temperature of 360° F., which is the point at which nitrate of ammonia itself decomposes, and if temperature is maintained between 360° and 390° F. great frothing occurs, and a constant stream of an invisible gas, which neither supports combustion nor is absorbed either by water or by solution of pyrogallic acid and potash, is evolved.

This gas is pure nitrogen, and is disengaged according to the following equation:

$$MnO_2+4NH_4NO_3=Mn2NO_3+8H_2O+6N.$$

320 grammes of ammonium nitrate should thus evolve 67,140 cubic centimetres of nitrogen at normal temperature and pressure.

An experiment, in which 3 grammes of ammonium nitrate were heated with an equal weight of manganese dioxide in a mercury bath to a temperature not above 400° F., yielded 606 cubic centimetres of nitrogen, a number sufficiently near to the theoretical amount 630 c.c. to show the above equation to be practically correct.

When the temperature is allowed to rise above 420° F., a more complex action ensues, the nitrate of manganese being apparently decomposed into manganese dioxide, nitrogen tetroxide, and oxygen.

An analysis of the gas evolved at 430° F., after passing it through water, gave the following results:

Gas taken, 12 c.c.; absorbed by water, nothing appreciable; after absorption by solution of pyrogallic acid and potash, 10·98 c.c. Amount of oxygen in 12 c.c. of gas = 1·02 percentage of oxygen, 8·5. As by the equation, $MnO_2+2NH_4NO_3=Mn2NO_3+N_2+2H_2O+H_2$, it was possible that hydrogen might be evolved, a special experiment was made with electrolytic gas and excess of oxygen by combustion in an eudiometer, but with negative results, no hydrogen being discoverable.

We are thus warranted in coming to the conclusion that at temperatures between 360° and 400° F. a mixture of equal weights of manganese dioxide and ammonium nitrate yield pure nitrogen, but that at temperatures above 420° tetroxide of nitrogen and oxygen are also evolved from the decomposition of the nitrate of manganese first formed.—*Chemical News.*

INCREASE OF WEIGHT BY COMBUSTION OF A SUBSTANCE.

M. V. MEYER suggests a form of lecture-room experiment to show the increase of weight in the combustion of a substance at the expense of the oxygen of the air. Some years ago Professor Hoffmann showed a practical method of demonstrating experimentally the increase of weight of iron when burned in oxygen, but there has been as yet no simple means of proving this fact for objects like a candle, which appear to the eye to diminish. A candle is attached to each pan of a balance, and above one a glass tube open at both ends is hung, at nearly the height of the wick. In this tube is a piece of wire gauze holding some pieces of caustic soda; after balancing the candles, one of the candles is lit, when the products of combustion are retained by the soda, and this end of the beam descends. At the end of a quarter of an hour the difference in weight may amount to three grams.—*Ber. Chem. Gesell.*

[ACADEMY.]

NOTES.

Electrical Conductivity and Electrolysis in Liquids.—Dr. Bleekrode has communicated to the Royal Society a preliminary paper on the researches he has been carrying out, partly by himself and partly in conjunction with Mr. Warren De la Rue, on the electrical behavior of certain liquids which have never been (in this way) operated on before. Many of these were liquefied gases—*e. g.* ammonia, cyanogen, hydrochloric acid, etc.—the liquefaction being effected by Faraday's method in strong glass tubes, which had platinum wires fused in at their extremities. The battery used was, in the first instance, one of eighty large Bunsen's cells, and afterwards the powerful one belonging to Mr. De la Rue, consisting of 8,000 chloride of silver cells. The electrodes were separated from each other by distances varying from two to four millimeters. The spark from an induction coil was also used, but with this apparatus the condensed gases generally exploded. As to the galvanic current, even the strongest did not pass in a perceptible degree through the following compounds (among others): liquid carbonic acid, liquid hydrochloric acid (or any other hydrogenized acid, as BrH, IH, with exception of CNH), liquid cyanogen, bisulphide of carbon, benzine, tetrachloride of carbon, zinc-ethyl. In the case of these liquids, when the electrodes were removed from the battery and connected with a delicate Thomson galvanometer, the index remained perfectly quiescent, this result indicating that no electrolysis had been taking place in the liquid. Liquid ammonia, however, forms a remarkable exception; it conducts the current even of a moderate battery, and is, at the same time, electrolyzed; the liquid becomes of an intensely blue color, and much gas is evolved. We shall look forward with interest to the more full account which Dr. Bleekrode has promised of these very interesting experiments.

Rotatory Magnetic Polarization.—In 1845 Faraday discovered that a powerful magnet exercises an action on many substances placed between its poles, such that if a ray of plane-polarized light traverses them in the direction of the line of the poles, the plane of polarization is deflected through a certain angle. The direction of displacement—according to the further experiments of Verdet—depends upon whether the medium between the poles is a diamagnetic or a paramagnetic substance. M. Henri Becquerel has lately presented to the French Academy an important memoir in which he endeavors to find some relation between the rotatory magnetic polarization of a substance and its refractive index, and has with this object investigated the optical properties of a great number of substances of high refracting power which have never before been examined from this point of view. It appears from the numbers given that the rotatory magnetic polarization increases with the refractive index, but much more rapidly than in a simple ratio. With respect to solutions of salts, it appears that the rotation increases with the concentration, and, moreover, that anomalous rotatory dispersion is accompanied by negative magnetic rotation. In connection with this subject we may mention some observations which have been made by Mr. G. F. Fitzgerald, on the subject of Dr. Kerr's experiment. It will be remembered that at the last meeting of the British Association Dr. Kerr announced the discovery that the plane of polarization of a ray of light reflected from the polished pole of a magnet is rotated. Mr. Fitzgerald offers an explanation of this remarkable fact by reference to the action of a diamagnetic transparent substance in a powerful magnetic field on a ray of plane-polarized light passing through it. The plane-polarized ray may be regarded as the resultant of two circularly-polarized rays, one right and the other left-handed, the former of which has a higher refractive index for the medium than the latter, if the rotation is toward the right, and a less, if the rotation is toward the left. Applying this consideration to the case of reflection of a polarized ray from the reflecting surface of a south magnetic pole, Mr. Fitzgerald arrives at the conclusion that the reflected beam is elliptically polarized, the major axis of the ellipse making a small angle to the right of the plane of incidence. This theoretical result was confirmed by a direct experiment, and appeared also to be in harmony with Dr. Kerr's experiments. We understand that Dr. Kerr has obtained some further results in addition to those which he communicated to the British Association. We shall be glad when these are published, so that we may see their bearing on Mr. Fitzgerald's conclusions.

Thermo-electric Currents produced in an Electrolyte.—A simple method of showing that a current is produced in a circuit containing an electrolyte when the two electrodes are maintained at different temperatures is described by W. Hellesen in a note in the *Comptes Rendus.* Two test-tubes, connected together by a short tube, are filled with the electrolyte (*e. g.*, copper sulphate). One of them contains a copper electrode near the bottom, the other (which can be heated by a spirit-lamp), a similar electrode, near the surface. The two electrodes can thus be maintained at different temperatures, and it is found that a current of considerable energy is developed, the current proceeding outwards from the electrode at higher temperature, which becomes promptly coated with a deposit of metallic copper. The electrolyte thus forms the battery by which its decomposition is effected.

Vibrations of Cylindrical Rods.—It is well known that the elasticity of a metal or alloy and the note it emits when struck so as to vibrate transversely are closely connected together. Decharme has recently (*Journ. de Phys.*), measured the rate of vibration of a number of metals in the form of rods about twenty centimeters long and one centimeter in diameter. They were supported by the two nodes, which were distant about four centrimeters from each end, and struck by a padded hammer in the center. The lowest note yielded was that from *lead*, which vibrated 690 times per second, the highest from *aluminium*, which was more than two octaves above the former. From these rates of vibration the elasticities of the metals were calculated according to the known laws of acoustics, and the results were compared with the corresponding elasticities found directly by Wertheim. The coincidences, except in a few cases, are not very close; nor was it to be expected that they would be, for the homogeneity of different specimens of even the same metal is never identically the same, and the specimens used by Wertheim and Decharme may have been widely different.

Manometers.—M. Cailletet, whose name is well known in connection with the subject of the behavior of gases under high pressures, has been using an open air manometer for high pressures, free from many of the difficulties of construction and fixing which formerly attached to this kind of apparatus. The tube, which is of metal, and about seventy meters long, rests upon the slope of a hill, at the foot of

which is the iron mercury reservoir where the pressure is produced. Marks are made on supports on the slope corresponding to successive vertical heights of 760 millimeters; and the upper extremity of the tube, which has a glass portion adapted to it, can be transported by reason of the flexibility of the metallic portion, up or down the slope, until the mercury appears in it, when the mercurial height can be read off by means of the fixed mark. The manometer described measure pressures up to twenty-five atmospheres, and has been used by M. Cailletet for the purpose of graduating closed glass manometers. He proposes to submit to further investigation the compressibility of gasses, by making use of the shaft of a mine for placing his pressure tube.

[NATURE.]

NOTES.

Exploring Balloons for Meteorological Purposes.—Since the beginning of February, M. Secretan, the optician of the Pont-neuf, in Paris, has been sending up regularly ever day at noon small exploring balloons for the purpose of ascertaining the direction of the several streams of air and the height of clouds. The results are daily published in the *Petit Moniteur*. The balloons are given gratuitously by the *Grand Magazin du Louvre*, and are of india rubber filled with pure hydrogen. The diameter is ninety centimeters—not quite three feet. M. de Fonvielle finds by calculation and by several experiments, that the mean velocity of elevation is about four meters per second. Hence, to obtain the altitude of the clouds, it is sufficient to observe the balloon with an opera glass to count the number of seconds necessary to lose sight of it, owing to the opacity of the clouds, and to multiply the number of seconds by four. It was found that the altitude of clouds varies from 400 to 800 meters (1,300 ft. to 2,600 ft.), and prospects of fair weather are increased in proportion to the elevation of clouds. The clouds follow the direction of an aërial stream in which they are wholly immersed, and are not placed, as has been repeatedly stated, at the surface of separation. The direction of the air for the first 100 meters is almost always very uncertain, and varies according to unknown causes. This shows that anemometers give a very poor idea not only of the velocity, but also of the direction of prevailing winds, and that no real progress is to be expected in the knowledge of atmospheric calculation as long as meteorologists confine themselves to taking into account anemometrical observations. Very often two different streams of air are observed, the lower one extending from 100 to 200 or 300 meters; under these circumstances the weather seems to be particularly uncertain and unsettled. Meteorologists, we think, might make use of this method of observation with great advantage.

Tungstate of Soda has been much talked about lately as valuable, when mixed with ordinary starch, for rendering muslin dresses uninflammable. Prof. Gladstone and Dr. Alder Wright have both brought it before audiences at the Royal Institution, Dr. Wright showing its efficacy by having a muslin dress so prepared for one of his assistants to wear, in which he walked about over flames. In repeating the demonstration in the course of a lecture at South Kensington, on Saturday evening, it was fortunate that Dr. Wright had the dress placed on a dummy instead of being worn by an assistant, for no sooner was the light applied to it than it blazed up and was consumed. Why this happened could not be explained, as it is believed no mistake had been made in the preparation. No doubt the exact conditions under which the tungstate is reliable will be a subject for further investigation.

On Accidental or Subjective Colors.—The *Bulletin* of the Belgian Academy of Science (vol. 42, Nos. 9 and 10) contains the second part of an interesting memoir by M. J. Plateau. The author had advanced, in 1834, a theory for the explanation of the subjective colors, and especially insisted on the circumstance that, after having looked for some time upon a colored body, we mostly do not see the true complementary color, but some other: the orange, for instance, instead of a pure yellow, after the blue; or a violet, instead of the blue, after the yellow. He explained it by supposing, firstly, that the retina, after having received the impression of some color, comes immediately into such a condition as if it were influenced by the opposite color, but that this subjective impression soon disappears, and reappears again, alternating with reappearing impressions of the primitive color of the colored body; and secondly, that similar phenomena take place also in space, *i.e.*, that the image of the colored body on the retina is surrounded, firstly, by a narrow strip of the same color as the body (which phenomenon we call irradiation), and then by a strip of opposite color, around which, under some circumstances, may reappear a third strip, of the color of the body looked upon. This theory having been much opposed since its appearance, especially in Germany and England, the author now discusses the various objections advanced against it; those relative to the first part of the theory were the subject of the first part of the memoir (*Bulletin*, vol. 39, 1875), and those relative to its second part are dealt with in this second memoir. The author begins his discussion with the objections against his theory of irradiation, dealing at great length with the opinions and objections of Helmholtz, and treating very skillfully the many difficulties of the whole question, among which the various myopy of the observers seems to be an important one. Further, the author criticises the theories of irradiation advanced until now (the imperfect accommodation of the eye, its spherical and chromatic aberration, and the diffraction at the borders of the pupil), and concludes that the fact that two neighboring irradiations may mutually neutralize each other, would alone be sufficient to condemn all these theories. The memoir is to be continued.

Radiometer.—A comparison has recently been made by Dr. Buff between the indications of the thermomultiplier and the radiometer. The two instruments were placed side by side in the cone of light admitted through an aperture of a board from a gas lamp, which could easily be regulated and kept constant for some minutes. There was a glass disk in front of the thermopile. In the galvanometer deflections of the needle were proportional to the deflecting force up to 21°. On tabulating deflections and numbers of rotations, it appears that their product is very nearly a constant number, warranting the inference that *the velocity of rotation of the little wheel is inversely proportional to the heat action of the penetrating rays.* This confirms the view that the turning of the radiometer is due to an action of heat rays which penetrate the glass. "If the radiometer," says Dr. Buff, "is incapable of measuring a mechanical force of light, it none the less wears its present name with full right. It is a special form of thermometer, only exclusively for heat rays of high refrangibility, whose heating force is proportional to the velocity of rotation of the wheel."

WHAT IS BATHYBIUS?

THE profound interest which general readers take in the discussions of the modern topics of evolution, origin of species, etc., has awakened much inquiry regarding the meaning of many of the words or terms employed in the great controversy. Among them *bathybius* and *protoplasm* are so used as to create distinctions which confuse the minds of those not well acquainted with the literature of the subject. "What is bathybius?" We answer (assuming the views of Huxley as formed several years since to be correct), bathybius is protoplasm, and protoplasm constitutes the lowest known manifestation of both animal and vegetable life. It is that mysterious substance which brings us *very near* to the boundary between the organic and inorganic worlds. Whether existing as a soft, gelatinous substance, the sarcode of the protozoa, the lowest form of animal life, or as the plastic mass in a seed or in the leaf-bud of an oak, it everywhere brings before us the first stage in acts of organization in which it is the chief if not the only actor. It, therefore, is evident that protoplasm is the most interesting substance in nature. The term "bathybius" has been applied by Professor Huxley to the vast masses of submarine protoplasm, which were proved to exist upon the bed of the ocean by the results of the soundings of Captain Daymon, of the British ship Cyclops, in 1857. A singular stickiness of the mud brought up by the lead, in soundings in various parts of the ocean, had been before observed, but it was not until Captain Daymon placed in the hands of Professor Huxley specimens for examination that its true nature was discovered. It is now known that vast areas of the bed of the ocean are covered with this low form of protoplasm. In order to its production, a certain degree of warmth seems to be necessary, and hence it is found usually in the track of the Gulf Stream. In Daymon's dredgings the viscid mud was brought up between the fiftieth and the forty-fifth degrees of west longitude; but other explorers have found it to exist in many localities, and it may be, as Dr. Carpenter suggests, common to all ocean beds where the temperature of the water rises to 45° F.

The discovery of submarine protoplasm, or "bathybius," as Huxley calls it, was indeed a startling one, inasmuch as it brought us apparently one step nearer to a solution of the problem of the origin of life. Among organized structures it is by far the lowest, and it is regarded by distinguished investigators as the missing link in the chain which binds the organic and inorganic worlds together. Deep down on the dark plains of the ocean a substance is found endowed with vital activities so low as to be hardly distinguishable from dead matter, from ordinary ocean silt, but yet possessing sufficient of the principle of life to form a starting point for all the forms in which animated nature exists. Now, if it could only be shown that bathybius starts out from dead matter, through a potency or force which is inherent in all such matter, the claims of materialists would rest upon better foundations than they do. If there is in the unorganized silt of the ocean bed, or in the warm waters which cover them, a potency which transforms the dead into living forms, then Professor Huxley's views are correct. It is good philosophical ground to rest upon; "aquosity and vitality" are correlated, and the mystery is solved. If there is no difference in the vital and physical forces, so far as the inherent and natural capabilities of pure unorganized matter are concerned, then life is spontaneous. The electrical force which transforms the elements of air into nitric acid is no lower or less supernatural than that which may transform ocean silt into bathybius; the force which causes the atoms of oxygen and hydrogen to combine to form molecules of water is physical, and so is that which endows protoplasm with life activities. This line of reasoning would be good if it rested upon observed facts and the analogies of nature, but it does not. There is a confusion of terms as well as of ideas concerning this matter. The forces of nature acting under inflexible laws we are able to comprehend in a measure, but the phenomena of life activities we do not understand. We know neither how they originate nor what is their nature only so far as they are related to chemical reactions, and those concern atomic and molecular changes in matter independent of life phenomena.

Unquestionably the study of protoplasm or bathybius has brought us nearer than before to a knowledge of the origin of that mysterious force which converts inorganic into organized material, but we have not reached the goal. We have increased our knowledge respecting the conditions of its existence, but not of its origin. It is easy to trace the action and development of protoplasm through successive generations of organisms, but, like the luminous ball of marsh damp, the more resolutely we approach to learn its origin the more determinedly the knowledge recedes from us. We have tried synthesis in our efforts to reach the unknown; we have combined the elements which enter into protoplasm, and so combined them as to insure absolute certainty of composition; we have arranged the atoms of oxygen hydrogen, carbon, and nitrogen with that consummate skill which modern science demands; we have placed them under the influence of the most subtle forces of nature, and yet we do not get protoplasm; our compounds do *not live!* The study of bathybius does not help us to a knowledge of what life is, and in our view, from the very nature of the problem, this ignorance will continue.

If this view tends to humble us, no harm, but probably good, will result. It is not derogatory to our powers and capabilities of research if it is proved that we are absolutely unable to bridge over the gulf which separates life from death. It requires a bridge of too wide a span to come within human possibilities; the work and the knowledge belong alone to a Supreme Mind, infinite in its power and capabilities.—*Boston Journal of Chemistry.*

A LIVE ANACONDA.

MR. FRAND BUCKLAND describes in *Land and Water* the arrival of a large snake at the Zoological Gardens: "With the commencement of the London season has arrived an illustrious visitor from South America. He is one of the largest of the *Boaidæ* family known to our generation. He is an anaconda (*Eunectes murinus*), which, as I translate it, means 'the good swimming mouse or deer eater.' This immense snake is now safely housed in the snake-house in the Zoological Gardens, under the parental care of Holland, who has for many years so ably managed the snakes, poisonous and non-poisonous. Our visitor arrived in Liverpool in a large box. Intelligence was given to Mr. Bartlett, who proceeded to Liverpool to inspect him, a matter of considerable difficulty. It will not do to buy an expensive snake of this kind without a warranty. Snakes are very liable to canker in the mouth. The gums get swollen and flabby, and completely conceal the teeth, so that the beast cannot feed. Again, if snakes are injured in the capture they frequently die in consequence. It was necessary to examine the snake as to these two points. Having been shut up for several months without food, and in the dark, the anaconda was not in a good temper. When the lid was opened Mr. Bartlett caught him tight round the neck with both hands; it was not necessary to open the mouth, as the savage snake did that soon enough of himself, in true anger. A moment's inspection showed he had no disease of the gums. It was with some difficulty that Mr. Bartlett got his head back into the box, without letting out more than a foot or two of his body. The anaconda has not poisonous teeth, but has great and dangerous powers of crushing. The box with the snake weighed over 200 lbs. It was with much dodging that the anaconda was conducted by two keepers to his new quarters, where he at once retreated into a bath of warm water, from which, as yet, he has only emerged once or twice. It is difficult to give the exact length of the snake, as he is not to be measured with as much facility as a fathom of rope. He is now lying in three parallel folds in his bath; we know the length of the bath, and we calculate his length to be between 18 and 20 feet—a tremendous fellow! It was impossible to get a tape measure round him; but, having measured his diameter in the thickest part, we conclude that he is over two feet round the body. At present he is thin, and his skin fits him very loosely. It is hoped that he will soon begin to feed. Mr. Bartlett, with his usual ingenuity, has found out how to make Mr. Anaconda feed. He covers his bath over at night, and puts therein with the snake a duck. The duck is always gone in the morning, and the snake appears fatter. Anaconda is decidedly nocturnal and aquatic in his habits. Like our own British snake, it is found in marshy, damp places, and he feeds upon animals which come down to drink at night. Mr. Bartlett has ascertained that the last meal this snake had consisted of a young peccary, the horny part of the hoofs having been discovered in the stones at the bottom of the cage; there are also the hairs of another animal which has to be diagnosed by microscopists. This tropical American snake is also called the Aboma. The provincial name is *El traga venado*, or the deer-swallower. He never interferes with men, although, of course, he will take his own part if attacked. It is greatly to be hoped that this magnificent snake will in time get an appetite and recover from his travel-worn appearance. His color may be described as buff, with very dark markings on the upper parts. His companion in the cage is a magnificently reticulated python (*Ular sawa*), caught at Penang. He has been at the Gardens since August, 1876, and has not eaten anything since he arrived. He shed his skin on Sunday, February 25th, and is now most lovely to behold. It would be impossible to describe the tints of the new skin (a splendid lacing of bronze, blue, gold, and black), except by saying that they are quite as gorgeous as the peacock's plumage."

THE EYES OF A FLOUNDER.

ALEXANDER AGASSIZ has published a most interesting fact in natural science. He thus describes the process by which the young flounder, which first has its eyes in the ordinary position, comes to have both organs at the same side of the body: "I captured one day a number of flounders (about an inch in length) closely allied to the Plagusiæ of Steenstrup, the so-called Bascania of Schiödte; they were so perfectly transparent that they seemed the merest film on the bottom of the glass vessel in which they were kept. They were still entirely symmetrical, the eyes well removed from the snout, with a dorsal fin extending almost to the nostril, far in advance of the anterior edge of the orbits of the eyes. They were, of course, at once set down (from their size) as belonging to a species of flounder in which the eyes probably remained always symmetrical, and I prepared to watch its future development. It was, therefore, with considerable interest that I noticed, after a few days, that one eye, the right, moved its place somewhat towards the upper part of the body, so that when the young fish was laid on its side, the upper half of the right eye could be plainly seen, through the perfectly transparent body, to project above the left eye. The right eye (as is the case with the eyes of all flounders), being capable of very extensive vertical movements, through an arc of nearly 180°, could thus readily turn to look through the body, above the left eye, and see what was passing on the left side, the right eye being, of course, useless on its own side as long as the fish lay on its side. I may mention here that this young flounder, until long after the right eye came out on the left side, continued frequently to swim vertically, and that for a considerable length of time. This slight upward tendency of the right eye was continued in connection with a motion of translation towards the anterior part of the head till the eye, when seen through the body from the left side, was entirely clear of the left eye, and was thus placed somewhat in advance and above it, but still entirely in the rear of the base of the dorsal fin extending to the end of the snout. What was my astonishment on the following day, on turning over the young flounder on its left side, to find that the right eye had actually sunk into the tissues of the head, penetrating into the space between the base of the dorsal fin and the frontal bone, to such an extent that the tissues adjoining the orbit had slowly closed over a part of the eye, leaving only a small elliptical opening, smaller than the pupil, through which the right eye could look when the fish was swimming vertically. While the young flounder lay on its side, the right eye was constantly used in looking through the body, and could evidently see extremely well all that took place on the left side. On the following day the eye had pushed its way still further through, so that a small opening now appeared opposite it, on the left side, through which the right eye could now see directly, the original opening on the right side being almost entirely closed. Soon after, this new opening on the left increased gradually in size, the right eye pushing its way more and more to the surface and finally looking outward on the left side with as much freedom as the eye originally on the left; the opening of the right side having permanently closed. I have thus in one and the same specimen been able to follow the passage of the eye from the right side to the left through the integuments of the head, between the base of the dorsal fin and the frontal bone." The author adds: "This observation leads to somewhat different conclusions from those of Steenstrup, who thought he could prove (from an examination of alcoholic specimens) that the eye from the right side passed under the frontal bone. This is evidently not the case here, the eye passing round it, there being only a very slight torsion of the frontal in this young stage. Although at first glance from the one described above, yet, if the dorsal fin had not extended beyond the posterior edge of the right orbit, the process would have been the same, as is readily seen."